TRACE METALS IN LAKE HURON WATERS -

1980 INTENSIVE SURVEILLANCE

by

Ronald Rossmann

Under Contract with:

United States Environmental Protection Agency

Grants R-005510-01-0, R-005510-02-0, and R-005510-03-0

Project Officer:

David C. Rockwell

Great Lakes National Program Office

United States Environmental Protection Agency

536 South Clark Street

Chicago, Illinois 60605

Special Report No. 97 of the
Great Lakes Research Division
Great Lakes and Marine Waters Center
The University of Michigan
2200 Bonisteel Blvd.
Ann Arbor, Michigan 48109

February 1983

DISCLAIMER

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement numbers R005510010, R005510020, and R005510030 to The University of Michigan, it has been subject to the Agency's peer and administrative review, and it has been approved for publication. The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (concluded)

LIST OF APPENDICES

ACKNOWLEDGMENTS

Thanks to Dr. Russell A. Moll and Dr. Kjell A. Johansen for reviewing the manuscript. Thanks to the Great Lakes National Program office, and especially David C. Rockwell, for their assistance. This work was supported by USEPA, Great Lakes National Program Office Grant Numbers R-005510-01-0, R-005510-02-0, and R-005510-03-0.

ABSTRACT

For water samples collected during the 1980 intensive surveillance of Lake Huron, a number of conclusions can be drawn. Total silver concentrations were higher in the epilimnion than the hypolimnion. Total cobalt concentrations exhibited no consistent vertical trend. In general, chromium concentrations were highest in the epilimnion. Total copper, manganese, iron, and arsenic were always highest at or above the thermocline. Metals consistently higher in concentration above the thermocline than below it are most likely high as a result of input to the lake. The horizontal variation of total metal concentrations from month to month were quite variable. Iron was always highest in southern Lake Huron and copper and manganese were highest in the North Channel for a limited number of observations (2 out of 3).

Total metals exhibited some variation with time. Silver, arsenic, cobalt, chromium, copper, iron, and manganese were highest in April 1980 in Georgian Bay. Metals showing a continuous decrease between April and July in Georgian bay include silver, cobalt, copper, iron, and manganese. In the North Channel, arsenic and cobalt were highest in mid-May. Silver, chromium, and iron were lowest in July. In general, highest total metal concentrations occurred in April and May for most metals. This may be associated with the spring melt and runoff.

The 1978 Water Quality Agreement objective for mercury was exceeded twice during 1980. This was most likely a result of sample contamination.

Because of the quality of historical data, predicting trace metal trends is difficult. Improvements in instrumentation and methodology has lowered detection limits and the amount of sample contamination. Thus, metals which

appear to be decreasing in concentration may appear so only because of the advancement of the science. The following trends are to be considered only tentative. A number of metals appear to be decreasing in concentration. These include dissolved arsenic, total cadmium, dissolved cadmium, dissolved copper, total lead, dissolved lead, total nickel, dissolved nickel, total zinc, and dissolved zinc. Total cobalt and total vanadium concentrations appear to have increased.

INTRODUCTION

As part of the intensive surveillance of Lake Huron during 1980, water samples for trace metal analysis were collected. Two sets of samples were collected. The first set was collected during the first four cruises. Samples were collected from a depth of 1 meter during the periods of April 13-16, May 16-21, May 29-June 5, and July 25-30. The stations collected during each cruise are listed in Table 1, and the locations are shown in Figure 1. At a few stations during the May 29-June 5 cruise, samples were collected at varying depths. All samples collected were analyzed for total metals only.

The second set of samples was collected during the July cruise. The samples were collected from 1 meter water depth at the stations shown in Figure 2. At each station, total metal, particulate metal (>0.5 μm diameter), and dissolved metal (<0.5 μm diameter) samples were collected. The methodology of collection, filtration, analysis, and data reduction are described in detail by Rossmann (1982). Comparisons of metal concentrations for different time periods and locations are done by comparing medians. Median was chosen as the best way to remove the large influence of outlier data points.

The first set of samples was analyzed at the United States Environmental Protection Agency Region V Central Regional Laboratory (CRL). The analyses were done by a contractor (MAR) using the method of standard additions with graphite furnace atomic absorption spectrophotometry. The second set of samples was analyzed at The University of Michigan Great Lakes Research Division Geochemistry Laboratory (GLRD) using the method of a standard curve graphite furnace atomic absorption spectrophotometry with background correction. The analyses were done under contract with the United States Environmental Protection Agency Great Lakes National Program Office.

Table 1. Trace metal sampling locations during 1980.

Station Number	Latitude, °N	Longitude, °W	April 13-16	May 16-21	May 29-June 5	July 25-30
1	43°05'24"	82°23'30"	x			
2	43 11 24	82 17 54	x			
3	43 15 25	82 02 18	x			
4	43 19 30	81 47 18	x			
5	43 32 54	81 44 42	x			
6	43 28 00	82 00 00	x			
7	43 20 30	82 30 24	x			
8	43 34 00	82 29 06	x			
9	43 38 00	82 13 00	x			
10	43 45 12	81 46 54	x			
11	43 57 24	81 47 12	x			
12	43 53 24	82 03 24	x			
13	43 45 12	82 34 06	x			
14	43 56 30	82 40 00	x			
15	44 00 00	82 21 00	x			
16	44 07 54	82 45 00	x			
17	44 06 00	82 52 00	x			
18	44 07 25	83 10 15	x			
19	44 09 00	82 58 00	x			
20	44 13 00	83 05 00	x			
21	44 16 00	83 12 00	x			
22	44 12 40	83 22 40	x			
23	44 20 00	83 18 0	x			
24	44 16 00	82 55 00	x			
25	44 23 00	83 16 00	x			
26	44 20 00	83 05 00	x			
27	44 11 54	82 30 12	x			
28	44 12 18	81 40 36				
29	44 22 00	81 50 00	x			
30	44 28 00	81 27 12	x			
31	44 51 00	81 36 00	x			
32	44 27 12	82 20 30	x			
33	44 30 00	82 50 00				
34	44 38 24	83 13 54	x			
35	44 51 00	83 15 42	x			
36	45 02 06	83 22 42	x			
37	44 45 42	82 47 00	x			
38	44 44 24	82 03 26				
39	44 39 24	81 22 42	x			
40	44 53 54	81 26 12	x			

(continued)

Table 1. Continued.

Station Number	Latitude, °N	Longitude, °W	April 13-16	May 16-21	May 29-June 5	July 25-30
41	45°05'00"	81°32'18"	x			
42	45 13 18	81 49 12	x			
43	45 00 48	82 00 30			x	
44	45 01 00	82 41 06			x	
45	45 08 12	82 59 00	x			
46	45 04 48	83 14 00	x			
47	45 15 18	83 20 48	x			
48	45 16 42	82 27 06	x			
49	45 24 48	81 55 06	x			
50	45 32 06	82 02 42	x			
51	45 32 00	82 16 48	x			
52	45 39 06	82 38 54	x			
53	45 27 00	82 54 54	x			
54	45 31 00	83 25 00	x			
55	45 23 30	83 39 06	x			
56	45 31 00	84 05 00	x			
57	45 40 00	83 43 36	x			
58	45 52 06	83 16 00	x			
59	45 46 00	83 01 42	x			
60	45 54 06	83 31 06	x			
61	45 45 00	83 55 00	x			
62	45 40 30	84 11 12	x			
63	45 42 12	84 30 42	x			
64	45 48 48	84 45 18	x			
65	45 50 42	84 34 00	x			
66	45 51 48	84 17 42	x			
67	45 56 06	83 54 00	x			
68	46 02 30	83 51 12	x	x		
69	46 04 42	84 01 42	x			x
70	46 08 12	83 40 18	x	x		x
71	46 14 00	83 44 48	x	x		
72	46 13 36	83 35 24	x	x		x
73	46 11 12	83 21 18	x			x
74	46 08 54	83 12 04	x			x
75	46 05 00	83 25 0	x			x
76	46 00 00	83 26 00	x			x
77	45 58 12	83 11 54	x			x
78	46 02 06	83 00 00		x	x	x
79	46 07 24	82 53 09		x		x
80	46 00 00	82 51 21			x	x

(continued)

Table 1. Continued.

Station Number	Latitude, °N	Longitude, °W	April 13-16	May 16-21	May 29- June 5	July 25-30
81	46°04'42"	82°44'36"			x	x
82	45 56 18	82 45 30		x	x	
83	46 00 00	82 33 00		x	x	
84	46 05 30	82 33 24		x	x	
85	46 06 00	82 25 30		x	x	
86	46 00 18	82 23 18			x	x
87	46 03 40	82 11 50		x	x	
88	46 03 20	82 00 00		x	x	
89	45 55 00	82 09 40		x	x	
90	43 24 00	82 18 00	x			
91	43 42 00	82 01 00	x			
92	43 48 30	82 22 00	x			
93	44 06 00	82 07 00	x			
94	44 04 10	83 04 50	x			
101	44 43 03	80 51 24	x			x
102	44 48 30	80 52 18	x			x
103	44 43 30	80 37 00	x			x
104	44 38 45	80 10 00	x			x
105	44 48 48	80 14 36	x			x
106	44 44 12	80 26 06	x			x
107	44 53 20	80 17 50	x			x
108	44 57 10	80 08 06	x			x
109	44 52 18	79 58 05				x
110	45 03 45	80 11 28	x			x
111	45 55 15	80 36 21	x			x
112	44 55 12	80 52 30	x			x
113	45 01 36	80 52 36	x			x
114	45 08 20	80 31 24	x			x
115	45 10 00	80 17 48	x	x		
116	45 21 13	80 29 12	x			x
117	45 14 42	80 52 30	x			x
118	45 09 10	81 04 03	x			x
119	45 04 00	81 15 14	x			x
120	45 13 00	81 13 36	x			x

(continued)

Table 1. Concluded.

Station Number	Latitude, °N	Longitude, °W	April 13-16	May 16-21	May 29- June 5	July 25-30
121	45°21'54"	81°11'24"	x			x
122	45 28 50	80 50 15	x			x
123	45 33 35	80 36 38	x	x		x
124	45 40 44	80 50 20	x			x
125	45 46 40	80 45 15	x	x		
126	45 50 00	80 54 00	x			x
127	45 52 00	81 00 00	x			
128	45 42 12	81 05 24	x			
129	45 35 00	81 05 00	x			
130	45 32 30	81 22 00	x			x
131	45 14 18	81 26 24	x			
132	45 16 12	81 35 00	x			
133	45 22 13	81 35 06	x			x
134	45 27 10	81 43 46	x			x
135	45 31 39	81 40 10	x			x
136	45 42 30	81 37 12	x			x
137	45 43 00	81 22 30	x			x
138	45 53 00	81 06 30	x	x		x
139	45 52 24	81 15 30	x	x		
140	45 51 52	81 32 08	x			
141	45 56 00	81 31 04	x			
142	45 54 46	81 35 42	x			
143	45 49 52	81 47 19	x			x
144	45 58 20	81 41 55	x	x		

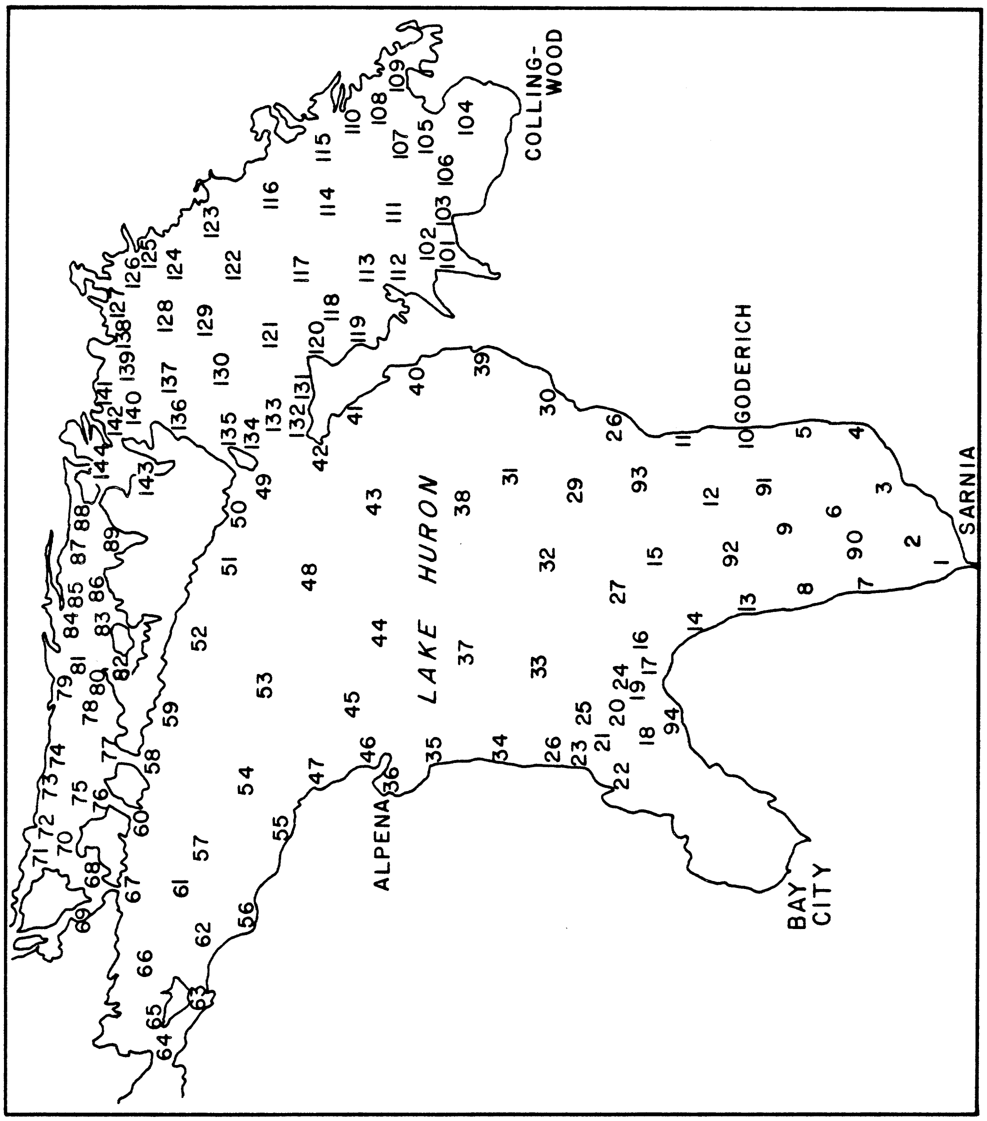

Figure 1. Stations sampled for total metals during 1980.

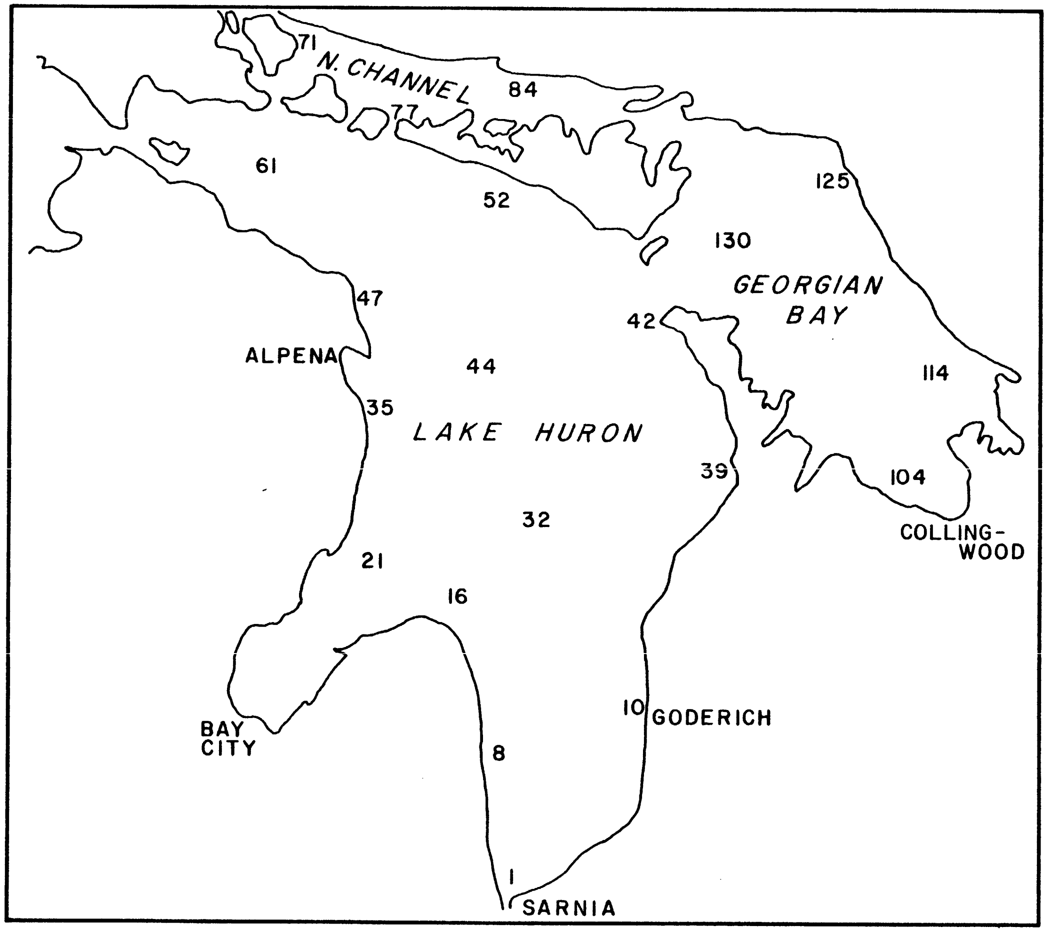

Figure 2. Stations sampled for total, dissolved, and particulate metals in July 1980.

RESULTS AND DISCUSSION

The complete data sets produced at each laboratory are listed in Appendices 1 and 2. In Appendix 1, the W code refers to the noise of the baseline as determined by the standards, and the T code refers to those results between the W value and two standard deviations of the blank. The data could not be blank corrected. In Appendix 2, the T code refers to all analyses less than two standard deviations of the blanks. All data were blank corrected. In each appendix, a -0. represents cases for which no measurement was made.

During the July collection period, four stations were sampled by each group using their method of collection. The collection apparatus used by MAR consisted of a sampling bottle connected to a PVC pipe. The PVC pipe had a measured mark on it so that a hole drilled in the pipe for collection would be 1 m below the surface. The collection apparatus used by GLRD was a metal free sampling device designed and reported by Rossmann (1982). Results of each laboratories analysis of its own samples are compared in Table 2. For most analyses, the comparisons are favorable. Notable exceptions include station 130 for silver, station 114 for arsenic, stations 77 and 114 for chromium, stations 104 and 114 for copper, station 130 for iron, and stations 104 and 114 for manganese.

For each period of collection, the total trace metal data are summarized in Tables 3 through 7. The Ag (silver), Co (cobalt), and Cr (chromium) data for April 13-16, Cr data for May 16-21, Co and Cr data for May 29-June 5, Ag, Co, and Cr data for July 25-30, and Hg and Pb data for July 18-28 are poor for predicting trends because from 26 to 85% of the samples had concentrations at or below the limit of detection.

Table 2. Comparison of USEPA (MAR) and GLRD results.

Element	Station	USEPA (MAR)[1]	GLRD[1,2]
Ag	77	0.01W	0.00080W (.0014)
	104	0.01W	0.014 (.0026)
	114	0.01W	0.011 (.0057)
	130	0.07	0.0034 (.0018)
As	77	0.13	0.14 (.018)
	104	0.10	0.14 (.0078)
	114	0.12	0.072 (.016)
	130	0.10	0.12 (.0064)
Cr	77	0.26	0.066 (.0038)
	104	0.16	0.13 (.0046)
	114	0.03W	0.12 (.00071)
	130	0.10	0.14 (.0057)
Cu	77	0.67	0.61 (.011)
	104	1.11	0.32 (.017)
	114	0.15T	0.47 (.0057)
	130	0.41	0.57 (.027)
Fe	77	5.03	5.3 (0.11)
	104	4.37	5.0 (.12)
	114	2.45	3.1 (.13)
	130	0.59T	1.4 (.070)
Mn	77	0.82	0.85 (.043)
	104	0.47	0.85 (.078)
	114	0.39	0.70 (.024)
	130	0.62	0.56 (.032)

[1]μg/L
[2]Mean followed by standard deviation

Table 3. Total trace metal concentrations (CRL) in surface waters (1 m) during April 13-26, 1980 ($\mu g/L$).[1,2]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection[3]
Ag	99	.17	.01	.81	.20	.16	54 (54)
Co	117	1.11	.14	6.67	1.67	1.41	57 (49)
Cr	121	.32	.01	2.38	.53	.47	31 (26)
Cu	120	1.26	.18	3.53	1.40	.77	1 (1)
Fe	117	12.7	4.31	261.	24.9	39.5	0 (0)
Mn	114	1.74	.48	54.7	2.69	5.18	10 (9)
As	121	.46	.10	1.04	.46	.17	3 (2)

[1]North Channel (10 stations); Georgian Bay (43 stations); Southern Lake Huron (20 stations); Central and Northern Lake Huron (48 stations).
[2]Data could not be blank corrected.
[3]Percent of number of cases in parentheses.

Table 4. Total trace metal concentrations (CRL) in surface waters (1 m) during May 16-21, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection[2]
Ag	19	.10	.01	.60	.17	.16	4 (21)
Co	19	2.50	.30	5.90	3.23	2.11	1 (5)
Cr	19	.08	.01	.32	.10	.10	15 (79)
Cu	19	.84	.03	4.04	1.0	.89	1 (5)
Fe	19	12.8	1.64	97.9	27.6	31.5	0 (0)
Mn	19	2.19	.10	12.2	2.78	2.74	1 (5)
As	19	.17	.02	.49	.16	.10	3 (16)

[1]North Channel (13 stations); Georgian Bay (6 stations).
[2]Percent of number of cases in parentheses.

Table 5. Total trace metal concentrations (CRL) in surface waters (1 m) during May 29–June 5, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection[2]
Ag	14	.07	.01	.22	.08	.06	1 (7)
Co	14	.26	.15	1.36	.52	.45	6 (43)
Cr	14	.14	.01	.35	.15	.10	4 (28)
Cu	14	.79	.10	1.45	.84	.43	1 (7)
Fe	14	9.63	4.80	29.0	14.5	8.60	0 (0)
Mn	14	2.22	1.57	5.87	3.10	1.67	0 (0)
As	14	.13	.05	.30	.14	.06	0 (0)

[1]Southern Lake Huron (1 station); Central Lake Huron (2 stations); North Channel (11 stations).
[2]Percent of number of cases in parentheses.

Table 6. Total trace metal concentrations (CRL) in surface waters (1 m) during July 25-30, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection[2]
Ag	46	.02	.01	.18	.03	.03	39 (85)
Co	46	.58	.04	2.17	.75	.57	15 (33)
Cr	46	.07	.01	1.13	.16	.25	23 (50)
Cu	46	.64	.10	2.74	.80	.64	8 (17)
Fe	46	4.02	.20	96.9	6.69	14.2	4 (9)
Mn	46	.80	.06	4.38	1.46	1.13	0 (0)
As	46	.13	.01	.28	.14	.06	3 (6)

[1]North Channel (13 stations); Georgian Bay (33 stations).
[2]Percent of number of cases in parentheses.

Table 7. Total trace metal concentrations (GLRD) in surface waters (1 m) during July 18-28, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection[2]
Ag	23	.0090	.00019	.042	.011	.0096	5 (22)
Al	23	8.8	2.5	26.	11.	6.4	0 (0)
As	23	.21	.072	.53	.25	.12	0 (0)
Cd	23	.015	.0017	.0607	.016	.013	3 (13)
Cr	23	.13	.032	.19	.12	.044	0 (0)
Cu	21	.40	.22	.64	.42	.13	0 (0)
Fe	23	4.8	1.4	25.	6.7	6.2	0 (0)
Hg	23	.011	0	.35	.060	.092	14 (61)
Mn	23	.67	.25	1.2	.74	.22	0 (0)
Ni	23	.54	.31	3.8	.83	.77	0 (0)
Pb	23	.022	0	.11	.038	.035	13 (56)
Se	23	.48	.16	1.2	.50	.20	0 (0)
V	23	.22	.10	1.1	.29	.22	0 (0)
Zn	21	.29	.12	.56	.31	.12	0 (0)

[1]Georgian Bay (4 stations); North Channel (3 stations); Southern Lake Huron (4 stations); Central and Northern Lake Huron and Saginaw Bay (12 stations).
[2]Percent of number of cases in parentheses.

For samples collected during the July cruise, dissolved and particulate metal concentrations were measured. The dissolved concentrations are summarized in Table 8. The Ag, Cd, Fe, Hg, Pb, and Zn concentrations were very low. They were so low that greater than 25% or more of the observations of each were below the limit of detection. Predicted trends for these metals are only qualitatively useful.

Particulate metal concentrations are summarized in Table 9. Those elements for which greater than 25% of the observations were below the limit of detection are As, Se, and V. As for the dissolved metal concentrations, predicted trends for these metals are only qualitatively useful.

Vertical Variation of Total Metals

During cruise 3 (May 29-June 5), water samples were collected from several depths. They were analyzed for total metal concentrations of Ag, Co, Cr, Cu, Fe, Mn, and As (Table 10). A total of eight stations were occupied for this purpose. Of the eight stations, five were in the early stages of stratification. These were stations 78, 81, 84, 87, and 89. At each, the thermocline was at a depth of 6 m or less. At station 78, either the nephloid layer was sampled or bottom sediments contaminated the sample. For most stratified stations, silver was higher in concentration above the thermocline than below it. Cobalt had no consistent vertical trend. In general, chromium was highest in concentration in the epilimnion. The copper, iron, manganese, and arsenic concentrations were always highest at or above the thermocline. For various metals, consistently higher concentrations above the thermocline than below it are attributable to inputs to the lake.

Table 8. Dissolved (<.5 μm diameter) metal concentrations (GLRD) in surface waters (1 m) during July 18-28, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection
Ag	23	.0058	.00012	.017	.0072	.0047	8
Al	23	3.1	.66	38.	6.0	8.0	0
As	23	.25	0	.75	.24	.19	5
Cd	23	0	0	.046	.0038	.010	21
Cr	23	.11	.0044	.38	.11	.078	2
Cu	21	.28	.063	.57	.30	.12	0
Fe	23	.80	0	11.	1.7	2.5	7
Hg	23	.0042	0	.36	.050	.090	20
Mn	23	.28	.12	.64	.27	.11	0
Ni	23	.49	.19	2.8	.64	.52	0
Pb	21	.0089	0	.081	.019	.026	15
Se	23	.48	.096	1.0	.52	.20	0
V	23	.24	.11	.60	.28	.15	0
Zn	21	.17	.026	.81	.26	.20	11

[1]Georgian Bay (4 stations); North Channel (3 stations); Southern Lake Huron (4 stations); Central and Northern Lake Huron and Saginaw Bay (12 stations).

Table 9. Particulate (>.5 μm diameter) metal concentrations (GLRD) in surface waters (1 m) during July 18-28, 1980 (μg/L).[1]

Element	Number of Cases	Median	Minimum	Maximum	Mean	Standard Deviation	Number of Observations at or Below Limit of Detection
Ag	23	.0013	.00067	.0031	.0013	.00057	0
Al	23	15.	2.9	72.	24.	20.	1
As	23	.0086	.00052	.017	.0080	.0046	14
Cd	23	.012	0.0	.15	.021	.031	2
Cr	23	.017	.0058	.068	.021	.014	0
Cu	20	.12	.014	.99	.24	.26	0
Fe	23	6.4	2.1	23.	8.4	6.1	0
Mn	23	.58	.18	3.0	.73	.62	0
Ni	23	.034	0.0	.086	.033	.023	4
Pb	23	.041	.0095	.14	.050	.034	1
Se	23	0.0	0.0	0.0	0.0	0.0	23
V	23	.014	.0026	.083	.017	.015	6
Zn	19	.33	.058	.91	.38	.26	3

[1]Georgian Bay (4 stations); North Channel (3 stations); Southern Lake Huron (4 stations); Central and Northern Lake Huron and Saginaw Bay (12 stations).

Table 10. Vertical variation in concentration of trace metals during the period of May 29 through June 5 (μg/L).[1]

Station	Depth (m)	Ag	As	Co	Cr	Cu	Fe	Mn
9	1	.04	.30	.60	.14	.55	25.	2.2
9	30	.04	.12	.58	.09T	1.02	26.	6.4
9	49	.01W	.01W	.15W	.01W	.11T	2.2	.31
43	1	.02	.08	1.3	.01W	.41	6.8	1.6
43	88	.02	.17	1.4	.13	1.05	4.8	2.4
43	66	.01W	.16	.62	.16	.31	.99	.08
44	1	.02	.14	.15W	.01W	.15	4.9	2.0
44	81	.02	.17	1.6	.11	.91	4.6	2.9
44	154	.04	.23	.54	.03T	.24	1.1	.10
78	1	.01W	.19	.49	.17	.10W	29.	5.9
78	12	.01W	.19	.56	.13	.17T	28.	6.1
78	35	.01W	.01W	.15W	.01W	.13T	1.9	.04W
78	43	.12	.07	.49	.09T	.10W	52.	12.
81	1	.17	.12	.15W	.07T	1.3	28.	5.9
81	16	.15	.12	.31T	.06T	1.5	26.	5.7
81	22	.01W	.08	.15W	.06T	.29	1.9	.15
84	1	.07	.12	.26T	.16	1.4	13.	3.3
84	6	.05	.11	.15T	.09T	1.4	18.	3.3
84	13	.02	.04	.15W	.05	.19	2.9	.28
87	1	.09	.13	.15W	.14	.69	8.1	2.9
87	5	.23	.19	.15W	.15	1.4	10.	2.4
87	11	.07	.10	.17T	.01W	.10	5.1	.33
89	1	.10	.13	.15W	.05T	.79	9.6	1.7
89	6	.02	.10	.15W	.05T	.79	9.6	1.8
89	20	.04	.10	.37	.08T	.32	2.6	.12

[1]W = noise of baseline as determined by a standard curve.
T = results between the W value and two standard deviations of the blank.

Horizontal Variation

Total metals

For various geographic regions of the lake, the median concentrations of metals have been compared for each of the four cruises. It should be noted that all areas were not sampled on each cruise. During the period of April 13-26, silver and manganese concentrations were highest in central and northern Lake Huron, chromium concentrations were highest in Georgian Bay, cobalt and iron were elevated in southern Lake Huron, copper was elevated in the mouth of Saginaw Bay, and arsenic had a relatively low concentration in southern Lake Huron (Table 11). Compared to Georgian Bay for the period of May 16-21, the North Channel had elevated concentrations of all metals except silver (Table 12). During the May 29 to June 5 sampling period, iron and arsenic concentrations were relatively high in southern Lake Huron (Table 13). Silver, copper, and manganese concentrations were highest in the North Channel (Table 13). Two data sets are available for July 1980. The first is CRL data. For all metals, concentrations were higher in the North Channel than in Georgian Bay (Table 14). This is somewhat similar to the results obtained by Rossmann (1982). Except for silver, chromium, lead, and selenium, metal concentrations in the North Channel were higher than in Georgian Bay (Table 15). Concentrations of silver, aluminum, arsenic, cadmium, chromium, and iron were highest in southern Lake Huron (Table 15). The highest concentrations of copper, mercury, manganese, nickel, vanadium, and zinc were found in the North Channel (Table 15). Georgian Bay had the highest concentrations of lead and selenium (Table 15).

Table 11. Median total metal concentrations (μg/L) for various regions of Lake Huron during April 13 - 26.

Element	Southern Lake Huron	Mouth of Saginaw Bay	Central & Northern Lake Huron	North Channel	Georgian Bay
Ag	.080	.19	.30	—	.17
As	.29	.49	.42	—	.49
Co	2.1	1.3	.50	—	1.5
Cr	.22	.21	.26	—	.48
Cu	1.1	1.5	1.3	—	.93
Fe	22.	14.	11.	—	8.7
Mn	1.8	1.6	2.1	—	1.5

Table 12. Median total metal concentrations (µg/L) for various regions of Lake Huron during May 16 - 21.

Element	Southern Lake Huron	Mouth of Saginaw Bay and Central and Northern Lake Huron	North Channel	Georgian Bay
Ag	--	--	.090	.10
As	--	--	.19	.12
Co	--	--	5.2	.86
Cr	--	--	.090	.010
Cu	--	--	.84	.50
Fe	--	--	13.	5.0
Mn	--	--	2.2	1.4

Table 13. Median total metal concentrations (μg/L) for various regions of Lake Huron during May 29 - June 5.

Element	Southern[1] Lake Huron	Mouth of Saginaw Bay	Central & Northern[2] Lake Huron	North Channel	Georgian Bay
Ag	.040	—	.020	.090	—
As	.30	—	.11	.13	—
Co	.60	—	.72	.26	—
Cr	.14	—	.010	.16	—
Cu	.55	—	.28	1.1	—
Fe	25.	—	5.6	13.	—
Mn	2.2	—	.28	2.9	—

[1]one station
[2]two stations in central Lake Huron

Table 14. Median total metal concentrations ($\mu g/L$) for various regions of Lake Huron during July 25-30.

Element	Southern Lake Huron	Mouth of Saginaw Bay and Central and Northern Lake Huron	North Channel	Georgian Bay
Ag	--	--	.020	.010
As	--	--	.18	.12
Co	--	--	1.2	.46
Cr	--	--	1.3	.090
Cu	--	--	1.3	.40
Fe	--	--	7.1	3.0
Mn	--	--	3.0	.64

Table 15. Median total metal concentrations ($\mu g/L$) for various regions of Lake Huron during July 18-28.

Element	Southern Lake Huron	Mouth of Saginaw Bay and Central and Northern Lake Huron	North Channel	Georgian Bay
Ag	.017	.0089	.00080	.0087
Al	12.	8.5	9.6	7.7
As	.27	.27	.16	.12
Cd	.019	.011	.015	.0058
Cr	.15	.12	.11	.12
Cu	.23	.38	.62	.47
Fe	14.	2.9	5.3	3.1
Hg	0.0	.013	.017	0.0
Mn	.73	.64	.85	.70
Ni	.33	.54	2.1	1.0
Pb	0.0	.020	.022	.028
Se	.41	.43	.41	.48
V	.22	.21	.33	.16
Zn	.21	.29	.51	.19

Dissolved Metals (<0.5 μm diameter)

The median concentrations of metals in various regions of the lake are tabulated in Table 16. Southern Lake Huron had the highest concentrations of aluminum, cadmium, iron, manganese, and lead. Central and northern Lake Huron, including the mouth of Saginaw Bay, had the highest concentrations of chromium and mercury. The North Channel had the highest concentrations of silver, arsenic, copper, nickel, and zinc. Finally, Georgian Bay had the highest concentrations of selenium and vanadium.

Particulate Metals (>0.5 μm diameter)

The median particulate metal concentrations for various regions of the Lake are summarized in Table 17. Aluminum, arsenic, and iron concentrations were highest in southern Lake Huron. In the mouth of Saginaw Bay and central and northern Lake Huron, concentrations of copper and zinc were highest. Lead was equally high in the North Channel and in the mouth of Saginaw Bay and central and northern Lake Huron. Other metals having their highest median concentrations in the North Channel were chromium, manganese, and nickel. The highest silver concentrations were in Georgian Bay and in the North Channel. Cadmium and vanadium concentrations were highest in Georgian Bay. At this point, it is necessary to comment on the lack of agreement of dissolved plus particulate concentrations with total concentration at any one station. This is very evident for those metals having a high proportion of their concentration in the particulate form. These differences are primarily related to problems analyzing total metal samples and are explained in Rossmann (1982). Thus, dissolved plus particulate is a better estimate for total metal concentrations.

Table 16. Median dissolved (<.5 μm diameter) metal concentrations (μg/L) for various regions of Lake Huron during July 18-28.

Element	Southern Lake Huron	Mouth of Saginaw Bay and Central and Northern Lake Huron	North Channel	Georgian Bay
Ag	.0054	.0054	.011	.0058
Al	4.0	2.2	3.1	3.0
As	.23	.27	.36	.12
Cd	.0033	0.0	0.0	0.0
Cr	.070	.12	.10	.092
Cu	.094	.38	.50	.30
Fe	2.7	.80	.38	.10
Hg	0.0	.036	0.0	0.0
Mn	.30	.26	.21	.20
Ni	.49	.49	.98	.66
Pb	.023	.015	0.0	0.0
Se	.41	.58	.37	.77
V	.12	.24	.22	.30
Zn	.085	.16	.27	.13

[1]μg/L

Table 17. Median particulate (>.5 μm diameter) metal concentrations (μg/L) for various regions of Lake Huron during July 18-28.[1]

Element	Southern Lake Huron	Mouth of Saginaw Bay and Central and Northern Lake Huron	North Channel	Georgian Bay
Ag	.0010	.00093	.017	.017
Al	49.	15.	14.	5.6
As	.0097	.0066	.0026	.0082
Cd	.0016	.012	.0070	.014
Cr	.0079	.020	.023	.015
Cu	.038	.26	.16	.12
Fe	15.	4.7	7.4	2.2
Mn	.45	.35	1.0	.59
Ni	.00070	.027	.058	.042
Pb	.018	.042	.042	.031
Se	--[2]	--[2]	--[2]	--[2]
V	.017	.010	.014	.023
Zn	.13	.49	.17	.18

[1]μg/L
[2]undetectable in all samples.

Time Variation of Total Metals

Total metals samples were collected from various regions of Lake Huron between April and July. Not enough stations were occupied for one of the time periods for southern (Table 18) and central and northern (Table 19) Lake Huron to allow any conclusions on seasonal changes to be made. Likewise, sampling occurred in the month of Saginaw Bay only in April (Table 20). However, sampling occurred in Georgian Bay (Table 21) and the North Channel (Table 22) at three different times. This permits conclusions on seasonal changes of metals in 1980 to be made.

In Georgian Bay, all metals were highest in April (Table 21). Metals which continuously decreased between April and July were silver, cobalt, copper, iron, and manganese. In the North Channel, arsenic and cobalt were highest in mid-May (Table 22). Silver, chromium, and iron were lowest in July. In general, highest total metal concentrations occurred in April and May for most metals. This may be associated with the spring melt and runoff.

United States - Canada Water Quality Agreement of 1978 Objectives

A product of the 1978 Water Quality Agreement between the United States and Canada are a set of pending and established objectives for the concentration of various metals in Great Lakes waters (International Joint Commission 1976). These are summarized in Table 23 along with the occurrences of 1980 metal concentrations exceeding the objectives. Only the objective for mercury was exceeded. Because it was exceeded on only two occasions and because the mercury analysis required pre-concentration by freeze-drying during which samples were intermittently contaminated, this must not be considered alarming (Rossmann 1982).

Table 18. Southern Lake Huron median total metal concentrations (μg/L) in water.

Element	April 13-26	May 16-21	May 29-June 5[1]	July 25-30
Ag	.080	--	.040	--
As	.29	--	.30	--
Co	2.1	--	.60	--
Cr	.22	--	.14	--
Cu	1.1	--	.55	--
Fe	22.	--	25.	--
Mn	1.8	--	2.2	--

[1]one station

Table 19. Central and northern Lake Huron median total metal concentrations ($\mu g/L$) in water.

Element	April 13-26	May 16-21	May 29-June 5[1]	July 25-30
Ag	.30	—	.020	—
As	.42	—	.11	—
Co	.50	—	.72	—
Cr	.26	—	.010	—
Cu	1.3	—	.28	—
Fe	11.	—	5.6	—
Mn	2.1	—	.28	—

[1]two stations in central Lake Huron

Table 20. Mouth of Saginaw Bay Lake Huron median total metal concentrations (μg/L) in water.

Element	April 13-26	May 16-21	May 29-June 5	July 25-30
Ag	.19	--	--	--
As	.49	--	--	--
Co	1.3	--	--	--
Cr	.21	--	--	--
Cu	1.5	--	--	--
Fe	14.	--	--	--
Mn	1.6	--	--	--

Table 21. Georgian Bay median total metal concentrations ($\mu g/L$) in water.

Element	April 13-26	May 16-21	May 29-June 5	July 25-30
Ag	.17	.10	--	.010
As	.49	.12	--	.12
Co	1.5	.86	--	.46
Cr	.48	.010	--	.090
Cu	.93	.50	--	.40
Fe	8.7	5.0	--	3.0
Mn	1.5	1.4	--	.64

Table 22. North Channel median total metal concentrations (μg/L) in water.

Element	April 13-26	May 16-21	May 29-June 5	July 25-30
Ag	—	.090	.090	.020
As	—	.19	.13	.18
Co	—	5.2	.26	1.2
Cr	—	.090	.16	.050
Cu	—	.84	1.1	1.3
Fe	—	13.	13.	7.1
Mn	—	2.2	2.9	3.0

Table 23. Occurrence of 1980 metal concentrations in Lake Huron equalling or exceeding Water Quality Agreement Objectives.

Element	Water Quality[1] Agreement Objectives	Number of Cases	Occurrences of Concentrations Greater than Objectives
As	50.	223	0
Cd	0.2	23	0
Cr	50.	223	0
Cu	5.	220	0
Fe	300.	219	0
Hg[2]	0.2	23	2
Ni	25.	23	0
Pb	20.	23	0
Se	10.	23	0
Zn	30.	21	0

[1] µg/L
[2] Total mercury in filtered lake water

Trends in Trace Metal Concentrations

Historical trace metal data are of two types, total concentration and filtered concentration. Within these data, a common operational distinction between dissolved and particulate is a particle diameter of 0.45 μm. Anything passing through a 0.45 μm pore size filter is considered soluble.

The bulk of historical data which exist for Lake Huron is contained in STORET, primarily Canada Centre for Inland Waters and State of Michigan data, and is reported, in part, in the International Joint Commission 1977 report "The Waters of Lake Huron and Lake Superior", Volume II, Parts A and B. In these volumes, tributary inputs are generally expressed as total metal concentrations. For the open lake, the data are a combination of total and filtered water concentrations. The Georgian Bay and North Channel 1974 data have been reported by Warry (1978a,b). The open lake data for 1980 are compared to the historical data in the following discussion.

Historical trace metal data for Lake Huron are available for the years 1965, 1968, 1970, 1971, 1974, 1975, 1976, 1977, and 1978. The data for all years excluding 1968 and 1975 are contained in STORET. Historical data must be used with caution for predicting trends. At the time of their generation, they may or may not have represented the best information available for the analytical state of the art. Instrumentation and methodology have improved considerably in the last ten years, especially the last five years. The need for caution is evident in many of the tables which follow. In many instances, dissolved metal concentrations are higher than total metal concentrations, suggesting a contamination of the dissolved metal samples during filtration. Many of the historical elemental concentrations are apparently at the limit of

detection; however, there is no indication of this in listings of the data. In many instances, concentrations for some metals are all the same, suggesting that the reported concentration is a limit of detection. When this is the case, it is indicated as such in the text which follows.

Aluminum

Historical total and dissolved aluminum data exist only for 1974 (Table 24). These data are of limited usefulness as they are at or near the limit of detection. Because of the nature of the historical data, little can be said about long-term trends.

Arsenic

Total arsenic data exist for 1974 and 1975 (Table 25). Some of the 1974 data were obtained under circumstances of a rather high limit of detection (1.0 μg/L). The 1980 mean and median concentrations are 2 to 3 times lower than those for 1974 and 1975. A combination of high limits of detection for 1974 and the location of collection for the 1975 samples make discerning a trend impossible.

Dissolved arsenic data exist for 1974 (Table 25). The data suggest arsenic concentrations may be decreasing. However, two points do not establish a trend.

Cadmium

Historical information for total cadmium is available for 1974 and 1976 (Table 26). The order or more of magnitude higher median concentration for 1974

Table 24. Comparison of 1980 to historical Lake Huron water aluminum concentrations (µg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1974	37.	12.	9	25.-30.	<20.	0.0	23	<20.
1980 (GLRD)	11.	6.4	23	8.8	6.0	8.0	23	3.1

Table 25. Comparison of 1980 to historical Lake Huron water arsenic concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1974	<1.	0.0	47	<1.	.50	.35	89	.4
1975[1]	.8	.1	10					
1980 (GLRD)	.25	.12	23	.21	.24	.19	23	.25
1980 (CRL)	.32	.21	217	.28				

[1]Nearshore waters; Poldoski *et al*. (1978).

Table 26. Comparison of 1980 to historical Lake Huron water cadmium concentrations ($\mu g/L$).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1970					1.0	0.0	2	1.
1971					.71	.51	111	1.
1974	.30	.16	42	.2	2.2	.22	70	.2
1976	.034	.038	38	.020	.057	.064	34	.030
1980 (GLRD)	.016	.013	23	.015	.0038	.010	23	0.0

data relative to the 1980 data leads to the conclusion that the 1974 data, which are at their limit of detection are of limited usefulness for predicting trends. The 1980 median concentration is 25% lower than that of 1976. Again, two points in time can not be used to established a trend.

Dissolved cadmium data are available for 1965, 1970, 1974, and 1976 (Table 26). The historical data for 1965, 1970, 1971, and 1974 appear to be at or near the limit of detection. The 1980 median concentration is considerably lower than that of 1976; however, a trend can not be predicted for only two points in time.

Cobalt

Historical data for total cobalt are available only for 1974 (Table 27). The 1974 data are at or near the limt of detection. The 1980 median concentration is more than four times that of 1974. Dissolved cobalt concentrations were not measured in 1980. However, the historical data are provided for the reader's information.

Chromium

Total chromium concentrations are available for 1968, 1970, and 1974 (Table 28). The 1970 and 1974 data are at or near the limit of detection. This makes the prediction of trends impossible.

Dissolved chromium data are available for 1965, 1968, 1970, 1971, and 1974 (Table 28). The 1965, 1971, and 1974 data are at or near the limit of detection. The 1970 data contain only one datum point, and the 1968 data are a mixture of total and dissolved results. Trend prediction is impossible.

Table 27. Comparison of 1980 to historical Lake Huron cobalt concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1970						.30	11	1.0
1971						.72	104	1.0
1974	.22	.055	25	.20				
1980 (CRL)	1.4	1.4	213	.87				

Table 28. Comparison of 1980 to historical Lake Huron water chromium concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1968[1]			37-39	1.6			37-39	1.6
1970	3.		1	3.	1.		1	1.
1971					.72	1.6	105	.1-.4
1974	1.3	.64	31	1.	.30	.24	128	.2
1980 (GLRD)	.12	.044	23	.13	.11	.028	23	.11
1980 (CRL)	.35	.42	217	.20				

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.

Copper

Total copper data exist for 1968, 1970, 1974, 1975, 1977, and 1978 (Table 29). The 1974 median of 1.0 represents a concentration obtained by discarding results which were quite high and most likely represented sample contamination. Based on 1980 CRL results, copper concentration appears to have been stable since 1974. Based on GLRD results, the copper concentration is decreasing. The difference in results may be due to the different collection times involved. Copper concentrations may be extremely seasonal (GLRD samples collected only in July).

Dissolved copper historical concentrations are available for 1965, 1968, 1970, 1971, 1974, 1976, 1977, and 1978 (Table 29). Results representing obvious contamination were discarded. The data of 1965, 1971, 1974, 1977, and 1978 are of limited usefulness for predicting trends because some of the results were at or near the limit of detection. With the data available, it appears that dissolved copper concentrations may be decreasing.

Iron

Total iron data exist for the years 1965, 1968, 1970, 1974, and 1975 (Table 30). For the years 1970 and 1974, obviously high results (contamination of samples) were discarded. Since 1965 and using 1980 GLRD results, the trend in total Fe concentration is downward. If CRL results are used, Fe may have a slight downward trend.

Dissolved iron data exist for the years 1970, 1971, 1974, and 1976 (Table 30). The data for all these years except 1971 may be at or near the limit of detection. As for total iron, dissolved iron concentrations appear to

Table 29. Comparison of 1980 to historical Lake Huron water copper concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1968[1]			37-39	3.			37-39	3.
1970	4.8	1.9	12	4.	3.5	3.2	23	1.
1971					3.7	2.5	187	1.
1974	2.4	2.3	96	1.	2.1	1.7	200	1.0
1975[2]	1.6	0.8	10					
1976					.78	.26	18	.5-1.
1977	1.8	1.3	44	1.0	2.8	1.8	39	3.0
1978	.75	.30	23	1.0	.72	.30	23	1.0
1980 (GLRD)	.42	.13	21	.40	.30	.12	21	.28
1980 (CRL)	1.1	.78	216	1.1				

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.
[2]Nearshore waters; Poldoski *et al*. (1978).

Table 30. Comparison of 1980 to historical Lake Huron water iron concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965	288.	265.	215	100.				
1968[1]			37-39	22.				
1970	21.	25.	12	12.-15.	6.3	8.4	23	1.
1971					3.2	2.7	182	2.-3.
1974[2]	21.	16.	94	2.-19.	2.7	2.6	119	1.-2.
1975[3]	18.	5.	10					
1976					2.0	1.9	18	.5
1980 (GLRD)	6.7	6.2	23	4.8	1.7	2.5	23	.80
1980 (CRL)	19.5	32.6	213	10.				

[1]Weiler and Chawla (1969).
[2]Concentrations above 50 μg/L excluded.
[3]Nearshore waters; Poldoski _et al_. (1978).

be decreasing since 1971. Because many of the data were at the limit of detection, the observed trend may be an artifact of improved detection limits.

Lead

Total lead data are available for 1968, 1970, 1974, 1975, 1977, and 1978 (Table 31). The 1977 and 1978 data are at or near the limit of detection. The trend in total lead concentration appears to be downward. The data of 1974 and earlier are suspiciously high.

Dissolved lead information exists for 1965, 1968, 1970, 1971, 1976, 1977, and 1978 (Table 31). The 1977 and 1978 data are at or near the limit of detection. All pre-1977 data are suspiciously high. The trend in dissolved lead concentration appears to be downward.

Manganese

Historical total manganese data exist for 1968, 1970, 1974, and 1975. The 1968 and 1970 data are at or near the limit of detection (Table 32). The trend of these data is oscillatory.

Dissolved manganese data are available for 1968, 1970, 1971, and 1974 (Table 32). The 1968, 1970, and 1971 data are at or near the limit of detection. The concentration of dissolved manganese has been stable since at least 1974.

Table 31. Comparison of 1980 to historical Lake Huron water lead concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1968[1]			37-39	2.7			37-39	2.7
1970	4.8	11.	13	2.	1.7	.80	21	1.-2.
1971					2.3	1.6	169	2.
1974	6.1	2.2	58	5.-7.	1.3	1.1	153	1.
1975[2]	.6	.2	10					
1976					1.0	0.0	18	1.
1977	.25	.25	43	.20	.23	.25	39	.10
1978	.21	.29	27	.10	.20	.26	27	.10
1980 (GLRD)	.038	.035	23	.022	.019	.026	21	.0089

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.
[2]Nearshore waters; Poldoski et al. (1978).

Table 32. Comparison of 1980 to historical Lake Huron water manganese concentrations (µg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1968[1]			37-39	<1.			37-39	<1.
1970	3.	5.4	12	1.	1.	0.0	4	1.
1971					.31	.33	167	.2
1974	3.2	3.6	111	2.	.43	.42	184	.2
1975[2]	1.3	.2	10					
1980 (GLRD)	.74	.22	23	.67	.27	.11	23	.28
1980 (CRL)	2.4	4.1	210	1.7				

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.
[2]Nearshore waters; Poldoski et al. (1978).

Mercury

Historical total mercury data are available for 1970 and 1974 (Table 33). The 1970 data appear to be at the limit of detection. Both the 1974 and 1980 data are at or near the limit of detection. The trend of decreasing concentration from 1970 through 1980 is a trend of improved detection limits.

Historical dissolved mercury concentrations are available for the years 1970, 1971, and 1974 (Table 33). All these data and those of 1980 are of limited usefulness because they are at or near the limit of detection. Again, the downward trend is one of improved technique.

Nickel

Total nickel data exist for the years 1968, 1970, and 1974 (Table 34). The 1970 and 1974 data are at or near the limit of detection. The trend of total nickel may be downward.

Dissolved nickel concentrations are available for 1965, 1968, 1970, 1971, 1974, and 1976 (Table 34). The 1970, 1974, and 1976 data are at or near the limit of detection. The dissolved nickel trend, like that of total nickel, may be downward.

Selenium

For both dissolved and total selenium, historical data exist for only 1974 (Table 35). The 1974 total selenium data are at or near the limit of detection. No total metal concentration trend can be established. The dissolved selenium trend appears to be upward. However, this is most likely an artifact of

Table 33. Comparison of 1980 to historical Lake Huron water mercury concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1970	1.	0.0	2	1.				
1970[1]					.17	.11	387-519	.2-.3
1971					.32	.45	178	.1-.3
1974	.053	.012	127	.05	.052	.0096	27	.05
1980 (GLRD)	.060	.092	23	.011	.050	.090	23	.0042

[1]Chau and Saitoh (1973); 387 samples for calculating mean and standard deviation and 519 samples for determining the median concentration.

Table 34. Comparison of 1980 to historical Lake Huron water nickel concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1968[1]			37-39	4.			37-39	4.
1970	1.3	.49	12	1.	1.4	.67	11	1.
1971					1.5	.99	176	1.
1974	2.1	2.1	15	1.	2.5	1.7	156	1.
1976					2.3	2.5	18	1.
1980 (GLRD)	.83	.77	23	.54	.64	.52	23	.49

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.

Table 35. Comparison of 1980 to historical Lake Huron water selenium concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1974	<1.	0.0	22	<1.	.12	.040	61	.1
1980 (GLRD)	.50	.20	23	.48	.52	.20	23	.48

methodology. By the 1974 method, the reduction of selenate to selenite, the form of selenium measured by the hydride method, may have been incomplete. The method used in 1980 was similar to that of 1974. However, the reduction of selenate to selenite was more vigorous. Thus, all the selenate was reduced instead of a fractional amount.

Vanadium

Only total metal historical data exist for vanadium (Table 36). The trend in total vanadium concentration since 1971 appears to be upward. However, two points do not establish a true trend.

Zinc

Total zinc data are available for 1968, 1970, 1974, 1976, 1977, and 1978 (Table 37). The trend in zinc concentration since 1968 appears to be downward. The concentration has changed little since 1977.

Historical dissolved zinc data exist for 1965, 1968, 1970, 1971, 1974, 1976, 1977, and 1978 (Table 37). A fair proportion of the 1977 and 1978 data are at or near the limit of detection. The trend in zinc concentration appears to be downward. However, it is quite likely that the older numbers represent sample contamination.

Table 36. Comparison of 1980 to historical Lake Huron water vanadium concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1971	.31	.24	37	.1				
1980 (GLRD)	.29	.22	23	.22	.28	.15	23	.24

Table 37. Comparison of 1980 to historical Lake Huron water zinc concentrations (μg/L).

	Total				Dissolved			
Year	Mean	Std. Dev.	N	Median	Mean	Std. Dev.	N	Median
1965					<5.	0.0	37	<5.
1968[1]			37-39	33.			37-39	33.
1970	4.4	2.8	12	4.	6.8	7.4	12	4.-6.
1971					7.3	4.8	174	6.-7.
1974[2]	5.0	2.4	67	3.-7.	5.1	2.4	68	1.-2.
1976[3]					2.4	.92	18	2.
1976	2.1	2.4	38	1.0	2.4	2.4	34	2.0
1977	.72	.56	43	.40	1.5	2.2	39	1.0
1978	.56	.45	27	.30	2.2	3.1	27	1.0
1980 (GLRD)	.31	.12	21	.29	.26	.20	21	.17

[1]Weiler and Chawla (1969); total and dissolved results were averaged together by the authors.
[2]Data >10 μg/L were excluded.
[3]Nearshore waters; Poldoski et al. (1978).

SUMMARY

Total silver concentrations were higher in the epilimnion than the hypolimnion. Total cobalt concentrations exhibited no consistent vertical trend. In general, chromium concentrations were highest in the epilimnion. Total copper, manganese, iron, and arsenic were always highest at or above the thermocline. Metals consistently higher in concentration above the thermocline than below it are most likely high as a result of input to the lake. The horizontal variation of total metal concentrations from month to month were quite variable. Iron was always highest in southern Lake Huron and copper and manganese were highest in the North Channel for a limited number of observations (2 out of 3).

Total metals exhibited some variation with time. Silver, arsenic, cobalt, chromium, copper, iron, and manganese were highest in April 1980 in Georgian Bay. Metals showing a continuous decrease between April and July in Georgian bay include silver, cobalt, copper, iron, and manganese. In the North Channel, arsenic and cobalt were highest in mid-May. Silver, chromium, and iron were lowest in July. In general, highest total metal concentrations occurred in April and May for most metals. This may be associated with the spring melt and runoff.

The 1978 Water Quality Agreement objective for mercury was exceeded twice during 1980. This was most likely a result of sample contamination.

Because of the quality of historical data, predicting trace metal trends is difficult. Improvements in instrumentation and methodology has lowered detection limits and the amount of sample contamination. Thus, metals which appear to be decreasing in concentration may appear so only because of the advancement of the science. The following trends are to be considered only

tentative. A number of metals appear to be decreasing in concentration (Table 38). These include dissolved arsenic, total cadmium, dissolved cadmium, dissolved copper, total lead, dissolved lead, total nickel, dissolved nickel, total zinc, and dissolved zinc (Table 38). Total cobalt and total vanadium concentrations appear to have increased (Table 38).

TRACE METALS IN LAKE HURON SEDIMENTS FOR DESCRIBING TRACE METAL TRENDS

Trace metal concentrations can be useful for documenting long-term trends. Unlike water data, reliable results are available which pre-date the settlement of the Lake Huron basin. The results are derived from the analysis of sediment cores which are dated using Pb-210. For Lake Huron, Robbins (1980) collected and analyzed numerous cores. These cores extended deep enough to sample pre-settlement sediments. By comparing recent surficial sediment concentrations to pre-settlement concentrations, he calculated enrichment factors for numerous metals. He found manganese, cadmium, copper, lead, nickel, and zinc to be consistently enriched in surficial sediments. Elements for which only a few cores were analyzed showed surficial enrichment of antimony, tin, and mercury. Elements which only occasionally showed surficial enrichment include iron, arsenic, chromium, barium, and molybdenum.

Similar work by Kemp and Thomas (1976) comparing pre-colonial and recent sediments showed mercury to be very slightly enriched and lead, zinc, cadmium, and copper to be enriched.

The background concentrations used by Kemp and Thomas (1976) and Robbins (1980) are summarized in Table 39. Included within the table are metal concentrations for the basins of Lake Huron where sediments are accumulating

Table 38. Summary of probable metal trends in Lake Huron water.

Metal	Trend Increase	Trend Decrease	None	Not Discernible From Data
Al				x
As		x		
Cd		x		
Co	x			
Cr				x
Cu		x		
Fe		x		
Hg				x
Pb		x		
Mn			x	
Ni		x		
Se				x
V	x			
Zn		x		

Table 39. Comparison of metal concentrations in recent sediments with those in older sediments (mg/Kg).

	Historical Concentrations		Recent Sediments[2]	
Metal	Kemp and Thomas (1976)	Robbins (1980)[1]	Lake Huron Basins	Georgian Bay and North Channel Basins
As		6.0	1.88	7.19
Cd	1.	1.6	1.3	2.01
Co		12.2	17.	24.
Cr		55.	43.	176.
Cu	38.	30.	46.	60.
Hg	.15	.03	.277	.392
Ni		35.	51.	119.
Pb	39.	30.	66.	67.
V		120.	54.	77.
Zn	94.	65.	86.	146.

[1]Derived from his data.
[2]Konasewich, *et al*. 1978.

(Konasewich, *et al*. 1978). Comparison of data sets leads to the conclusion that cobalt, chromium, copper, mercury, nickel, lead, and zinc are accumulating in recent sediments at concentrations above historical levels. Because the metals Co, Mn, Cd, Cu, Pb, Ni, Zn, Fe, As, Cr, Sb, Sn, Hg, Ba, and Mo are enriched in recent sediments and because contaminants get to the sediments by transport through the water column, total metal concentrations in water for these elements may be elevated over historical concentrations.

LITERATURE CITED

International Joint Commission. 1976. The waters of Lake Huron and Lake Superior, Vol. I. Summary and recommendations. Upper Lakes Reference Group, 236 pp.

International Joint Commission. 1977. The waters of Lake Huron and Lake Superior, Vol. II. Lake Huron, Georgian Bay, and the North Channel. Upper Lakes Reference Group, 743 pp.

Kemp, A. L. W., and R. L. Thomas. 1976. Impact of man's activities on the chemical composition in the sediments of Lakes Ontario, Erie, and Huron. Water, Air, and Soil Pollution 5:469-490.

Konasewich, D., W. Traversy, and H. Zar. 1978. Status report on organic and heavy metal contaminants in the Lakes Erie, Michigan, Huron, and Superior Basins. A report to the Implementation Committee of the Great Lakes Water Quality Board, International Joint Commission, 373 pp.

Poldoski, J. E., E. N. Leonard, J. T. Fiandt, L. E. Anderson, G. F. Olson, and G. E. Glass. 1978. Factors in the determination of selected trace elements in near-shore U. S. waters of Lakes Superior and Huron. J. Great Lakes Res. 4:206-215.

Robbins, J. A. 1980. Sediments of southern Lake Huron: elemental composition and accumulation rates. USEPA Report No. EPA-600/3-80-080.

Rossmann, R. 1982. Trace metal chemistry of the waters of Lake Huron. The University of Michigan, Great Lakes Research Division Publ. No. 21.

Warry, N. D. 1978. Chemical limnology of Georgian Bay, 1974. Inland Waters Directorate, Ontario Region, Water Quality Branch, Scientific Series No. 91, 13 pp.

Warry, N. D. 1978. Chemical limnology of the North Channel, 1974. Inland Waters Directorate, Ontario Region, Water Quality Branch, Scientific Series No. 92, 12 pp.

Weiler, R. R., and V. K. Chawla. 1969. Dissolved mineral quality of the Great Lakes waters, pp. 801-818. In: Proc. 12th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res.

APPENDIX 1

United States Environmental Protection Agency Region V

Central Regional Laboratory

Lake Huron (1980) Trace Metal Results for Water

CRUISE 1

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO (UG/L)	TOTAL CR (UG/L)	TOTAL CU (UG/L)	TOTAL FE (UG/L)	TOTAL MN (UG/L)	TOTAL AS (UG/L)
LH1	4/13/80	0704	1.	.010000	4.170000	1.800000	.710000	22.100000	.930000	.360000
LH2	4/13/80	0845	1.	.03000T	5.000000	.16000T	1.310000	21.500000	1.310000	.430000
LH3	4/13/80	1030	1.	.03000T	3.330000	.230000	2.940000	65.500000	1.920000	.290000
LH4	4/13/80	1152	1.	.12000T	3.330000	.270000	1.250000	18.600000	1.530000	.530000
LH5	4/13/80	1333	1.	.01000T	1.600000	.220000	1.250000	98.600000	2.530000	.290000
LH6	4/13/80	1510	1.	.11000T	5.080000	.270000	1.110000	17.400000	.740000	.290000
LH7	4/13/80	1832	1.	.08000T	5.330000	.01000T	.830000	261.000000	1.810000	.250000
LH8	4/13/80	2044	1.	.08000T	.52000T	.14000T	.20000T	11.200000	.480000	.320000
LH9	4/13/80	2230	1.	.08000T	.52000T	.14000T	1.040000	13.400000	.870000	.390000
LH10	4/14/80	0158	1.	.370000	.38000T	.02000T	.300000	52.100000	1.520000	.390000
LH11	4/14/80	0402	1.	.810000	.67000T	.230000	.540000	79.500000	1.310000	.220000
LH12	4/14/80	0537	1.	.13000T	.540000	.250000	1.040000	17.500000	2.080000	.290000
LH13	4/14/80	0851	1.	.080000	2.000000	.290000	1.370000	34.400000	2.280000	.350000
LH14	4/15/80	0617	1.	.06000T	4.810000	.500000	1.670000	71.000000	3.530000	.280000
LH15	4/15/80	0802	1.	.13000T	2.120000	.14000T	1.830000	14.200000	2.460000	.210000
LH16	4/15/80	1343	1.	.220000	.56000T	.220000	1.420000	11.800000	-0.	.420000
LH17	4/15/80	1458	1.	.650000	1.26000T	.270000	1.010000	18.500000	1.560000	.410000
LH18	4/16/80	1120	1.	.270000	1.760000	.15000T	1.510000	32.000000	2.320000	.10000T
LH19	4/15/80	1640	1.	.04000T	1.07000T	.12000T	1.710000	14.000000	1.740000	.540000
LH20	4/16/80	1315	1.	.07000T	1.480000	.16000T	2.060000	10.500000	1.560000	.540000
LH21	4/16/80	1745	1.	.04000T	1.760000	.220000	1.570000	6.440000	1.590000	.540000
LH22	4/16/80	1002	1.	.19000T	.14000T	.300000	1.510000	31.400000	3.040000	.620000
LH23	4/16/80	1845	1.	.19000T	1.480000	.220000	2.960000	18.800000	1.590000	.580000
LH24	4/16/80	1400	1.	.370000	.66000T	.19000T	1.660000	14.200000	1.590000	.490000
LH25	4/16/80	1002	1.	.320000	.50000W	.210000	1.330000	14.700000	1.430000	.620000
LH26	4/16/80	1630	1.	.04000T	3.300000	.18000T	1.920000	8.570000	1.590000	.490000
LH27	4/15/80	1210	1.	.240000	1.850000	.270000	1.110000	7.930000	5.880000	.210000
LH29	4/22/80	2337	1.	-0.	-0.	-0.	-0.	-0.	-0.	-0.
LH30	4/23/80	0203	1.	.300000	1.11000T	.14000T	2.960000	15.800000	1.290000	.410000
LH31	4/23/80	0736	1.	.510000	.50000W	.320000	2.330000	-0.	1.590000	.740000
LH32	4/22/80	2100	1.	.280000	1.00000T	.220000	2.180000	15.500000	2.220000	.410000
LH34	4/16/80	2053	1.	.380000	1.110000	.18000T	2.220000	13.300000	1.490000	.340000
LH35	4/16/80	2250	1.	-0.	.790000	.350000	1.080000	14.700000	2.520000	.410000
LH36	4/17/80	0025	1.	-0.	.50000T	.280000	.850000	15.800000	2.000000	.950000
LH37	4/22/80	1737	1.	-0.	2.820000	.240000	1.590000	10.700000	1.620000	.13000T
LH39	4/23/80	0437	1.	.320000	.700000	.220000	2.630000	37.700000	1.880000	.370000
LH40	4/23/80	0635	1.	.260000	.50000T	.14000T	2.330000	50.700000	1.490000	.450000
LH41	4/18/80	0705	1.	-0.	.50000T	.250000	1.820000	19.900000	1.900000	.310000
LH42	4/18/80	0902	1.	-0.	.50000T	.270000	.780000	7.280000	2.220000	.420000
LH43	4/18/80	0401	1.	-0.	.50000T	.370000	3.330000	10.300000	2.100000	.450000
LH44	4/17/80	2047	1.	-0.	.50000T	.530000	1.050000	6.670000	2.000000	.530000
LH45	4/17/80	2050	1.	-0.	.50000T	.320000	.780000	11.400000	2.100000	.500000
LH46	4/17/80	1925	1.	-0.	.50000T	.260000	1.300000	9.840000	2.100000	.390000
LH47	4/18/80	2030	1.	-0.	.57000T	.280000	.950000	9.640000	4.030000	.500000
LH48	4/18/80	0107	1.	-0.	.50000W	.13000T	.540000	16.600000	2.300000	.370000
LH49	4/18/80	1101	1.	-0.	1.00000T	.270000	1.280000	10.500000	2.840000	.500000
LH50	4/18/80	1227	1.	-0.	.50000W	.290000	.860000	8.750000	2.050000	.420000
LH51	4/18/80	1347	1.	-0.	.50000W	.260000	.240000	7.620000	2.290000	.530000
LH52	4/18/80	1555	1.	-0.	.53000T	.05000T	1.430000	11.300000	2.050000	.640000

CRUISE 1

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO (UG/L)	TOTAL CR (UG/L)	TOTAL CU (UG/L)	TOTAL FE (UG/L)	TOTAL MN (UG/L)	TOTAL AS (UG/L)
LH53	4/18/80	1755	1.	-0.	.33000T	.200000	2.810000	16.600000	2.420000	.340000
LH54	4/19/80	0020	1.	-0.	.16000T	1.030000	2.040000	12.000000	1.640000	.420000
LH55	4/18/80	2245	1.	-0.	.53000T	1.010000	.620000	13.600000	2.250000	.370000
LH56	4/19/80	0834	1.	.21000T	1.06000T	.860000	1.200000	19.800000	5.160000	.610000
LH57	4/19/80	0615	1.	.240000	.73000T	.530000	1.510000	14.700000	5.190000	.810000
LH58	4/21/80	0645	1.	.18000T	.890000	.550000	2.120000	9.620000	5.380000	.470000
LH59	4/19/80	0259	1.	-0.	.730000	1.700000	2.120000	12.300000	4.600000	.500000
LH60	4/20/80	2024	1.	.14000T	3.330000	1.470000	1.310000	10.700000	2.380000	.280000
LH61	4/20/80	1312	1.	.08000T	1.790000	.11000T	.550000	13.100000	1.960000	.580000
LH62	4/19/80	0958	1.	.21000T	.45000T	1.040000	1.300000	15.900000	5.030000	.290000
LH63	4/19/80	1148	1.	.230000	.50000W	.960000	.830000	17.500000	4.250000	.470000
LH64	4/20/80	0825	1.	.250000	3.330000	.810000	1.010000	16.600000	1.250000	.640000
LH65	4/20/80	0933	1.	.20000T	1.850000	.530000	1.150000	15.100000	1.970000	.470000
LH66	4/20/80	1100	1.	.300000	3.330000	.18000T	1.660000	11.800000	2.310000	.420000
LH67	4/20/80	1441	1.	.310000	1.28000T	.450000	1.880000	110.000000	4.720000	.260000
LH68	4/20/80	1548	1.	.310000	-0.	.680000	1.670000	240.000000	5.810000	.340000
LH69	4/20/80	1652	1.	.04000T	1.350000	1.350000	1.660000	132.000000	3.610000	.770000
LH70	4/21/80	1119	1.	.13000T	.80000T	.80000T	1.660000	33.900000	3.030000	.660000
LH71	4/21/80	1230	1.	.350000	1.720000	1.720000	2.370000	160.000000	8.030000	.850000
LH72	4/21/80	1320	1.	.21000T	2.380000	2.380000	1.250000	72.700000	2.940000	.620000
LH73	4/21/80	1440	1.	.21000T	1.11000T	1.11000T	1.250000	41.700000	2.630000	.740000
LH74	4/21/80	1537	1.	.11000T	.50000W	.50000W	3.330000	19.500000	-0.	.590000
LH75	4/21/80	0922	1.	.250000	2.120000	2.120000	.830000	12.700000	1.370000	.510000
LH76	4/20/80	2130	1.	.06000T	1.28000T	1.28000T	1.230000	10.700000	1.570000	.310000
LH77	4/21/80	0757	1.	.03000T	.50000W	.50000W	2.870000	7.100000	-0.	.470000
LH90	4/13/80	1705	1.	.03000T	1.20000T	.840000	1.670000	12.700000	1.430000	.570000
LH91	4/14/80	2418	1.	.03000T	.89000T	.10000T	.300000	26.200000	1.830000	.350000
LH92	4/14/80	0732	1.	.11000T	3.330000	.190000	1.050000	9.470000	1.840000	.280000
LH93	4/15/80	0950	1.	.01000T	3.940000	.19000T	2.260000	17.500000	2.430000	.150000
LH94	4/16/80	1209	1.	-0.	2.440000	.480000	1.530000	-0.	.51000T	.180000
LH101	4/25/80	0500	1.	.17000T	4.870000	.450000	2.180000	10.200000	1.590000	.490000
LH102	4/25/80	0342	1.	.17000T	1.670000	.480000	1.780000	11.300000	1.630000	.740000
LH103	4/24/80	0205	1.	.03000T	3.330000	.380000	1.720000	14.500000	1.520000	.330000
LH104	4/24/80	2310	1.	.03000T	5.150000	.320000	2.000000	15.000000	1.670000	.520000
LH105	4/24/80	2151	1.	.20000T	3.330000	.250000	1.180000	17.900000	1.560000	.490000
LH106	4/24/80	0055	1.	.13000T	6.670000	.330000	1.250000	11.700000	1.670000	.490000
LH107	4/24/80	0255	1.	.06000T	2.860000	.370000	1.610000	12.000000	1.600000	.290000
LH108	4/25/80	1341	1.	.17000T	3.940000	.12000T	.740000	6.380000	1.520000	.490000
LH110	4/25/80	1443	1.	.17000T	3.840000	.13000T	.18000T	7.200000	1.520000	.330000
LH111	4/24/80	1918	1.	.17000T	.740000	.390000	.590000	6.760000	1.330000	.460000
LH112	4/24/80	1800	1.	.01000W	3.810000	.440000	.970000	18.200000	1.870000	.330000
LH113	4/24/80	1651	1.	.10000T	.980000	.270000	1.170000	10.000000	.98000T	.670000
LH114	4/25/80	1710	1.	.13000T	.50000W	.640000	.930000	8.060000	1.03000T	.420000
LH115	4/25/80	1550	1.	.06000T	3.330000	.10000T	.370000	5.330000	1.870000	.260000
LH116	4/25/80	1845	1.	.13000T	.50000W	.926000	.270000	6.270000	1.280000	.550000
LH117	4/24/80	1227	1.	.190000	2.820000	.180000	.770000	11.800000	.93000T	.390000
LH118	4/24/80	1347	1.	.210000	3.330000	.330000	.590000	9.490000	1.760000	.630000
LH119	4/24/80	1505	1.	.08000T	2.820000	.290000	.590000	7.440000	.67000T	.590000
LH120	4/24/80	1027	1.	.130000	1.900000	.290000	.410000	5.630000	1.070000	.520000

CRUISE 1

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO (UG/L)	TOTAL CR (UG/L)	TOTAL CU (UG/L)	TOTAL FE (UG/L)	TOTAL MN (UG/L)	TOTAL AS (UG/L)
LH121	4/24/80	0906	1.	.420000	2.310000	.17000T	.700000	7.140000	.93000T	.200000
LH122	4/25/80	2230	1.	.400000	.50000W	.830000	.630000	8.670000	2.550000	.320000
LH123	4/25/80	2100	1.	.240000	.50000W	.540000	.740000	23.000000	2.580000	.590000
LH124	4/26/80	0603	1.	.500000	1.28000T	.600000	1.000000	7.800000	1.130000	.660000
LH125	4/26/80	0710	1.	.280000	.26000T	.850000	.590000	-0.	8.330000	.550000
LH126	4/26/80	0813	1.	.220000	.26000T	1.160000	2.260000	34.600000	2.170000	.660000
LH127	4/26/80	0900	1.	.230000	-0.	.450000	3.530000	-0.	54.700000	.510000
LH128	4/26/80	0428	1.	.560000	1.28000T	.540000	1.780000	7.870000	1.06000T	.590000
LH129	4/25/80	2355	1.	.280000	.50000W	.720000	.740000	6.480000	1.600000	.250000
LH130	4/26/80	0125	1.	.17000T	.50000W	1.340000	1.400000	10.600000	1.06000T	.700000
LH131	4/24/80	0726	1.	-0.	3.330000	.17000T	.670000	5.860000	.97000T	.590000
LH132	4/24/80	0612	1.	-0.	.50000W	.08000T	.330000	6.670000	1.390000	.490000
LH133	4/26/80	2150	1.	.100000	2.720000	.940000	.420000	4.310000	1.110000	.440000
LH134	4/26/80	2040	1.	.410000	1.660000	.900000	.750000	4.760000	1.06000T	.290000
LH135	4/26/80	1950	1.	.710000	.50000W	.580000	.670000	7.390000	.970000	.360000
LH136	4/26/80	1825	1.	.350000	1.790000	.120000	1.330000	8.880000	1.590000	.660000
LH137	4/26/80	0255	1.	.120000	-0.	.710000	1.260000	7.500000	1.520000	.290000
LH138	4/26/80	0948	1.	.18000T	-0.	1.200000	1.670000	109.000000	11.800000	.320000
LH139	4/26/80	1042	1.	.370000	.56000T	1.000000	-0.	14.900000	-0.	.290000
LH140	4/26/80	1705	1.	.13000T	.50000W	1.670000	.370000	15.000000	1.110000	.590000
LH141	4/26/80	1205	1.	.01000T	1.510000	1.160000	2.900000	10.600000	1.300000	.700000
LH142	4/26/80	1235	1.	.110000	1.330000	1.370000	2.670000	6.520000	-0.	1.040000
LH143	4/26/80	1400	1.	.110000	1.510000	.640000	2.870000	10.300000	-0.	.590000
LH144	4/26/80	1519	1.	.040000	.91000T	1.140000	2.670000	7.780000	-0.	.510000

CRUISE 2

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO	TOTAL CR	TOTAL CU	TOTAL FE	TOTAL MN	TOTAL AS
LH68	5/16/80	0705	1.	.03000T	5.740000	.10000T	.290000	88.300000	2.210000	.190000
LH70	5/16/80	1015	1.	.01000W	5.900000	.250000	.300000	31.200000	2.330000	.190000
LH71	5/16/80	1110	1.	.03000T	5.680000	.320000	1.240000	88.300000	3.650000	.210000
LH72	5/16/80	1215	1.	.01000W	5.740000	.200000	1.140000	97.900000	2.190000	.180000
LH78	5/17/80	0550	1.	.230000	5.560000	.270000	.840000	6.450000	.10000W	.190000
LH79	5/17/80	0705	1.	.090000	5.490000	.04000T	.810000	29.800000	.740000	.170000
LH82	5/17/80	1020	1.	.420000	4.820000	.15000T	4.040000	12.800000	5.270000	.170000
LH83	5/17/80	1130	1.	.050000	5.170000	.05000T	1.240000	10.600000	.300000	.150000
LH84	5/17/80	1215	1.	.370000	2.500000	.03000T	1.340000	46.400000	12.200000	.020000
LH85	5/17/80	1310	1.	.160000	.300000	.04000T	1.010000	6.820000	3.330000	.110000
LH87	5/17/80	1525	1.	.020000	2.240000	.09000T	.150000	1.640000	1.390000	.490000
LH88	5/17/80	1806	1.	.290000	2.500000	.01000W	.710000	6.450000	1.640000	.190000
LH89	5/17/80	1630	1.	.190000	2.170000	.09000T	.720000	3.950000	1.640000	.190000
LH115	5/20/80	2234	1.	.210000	.870000	.01000W	.10000W	3.120000	1.330000	.05000T
LH123	5/21/80	0336	1.	.040000	.860000	.01000W	1.350000	14.900000	3.200000	.190000
LH125	5/21/80	1000	1.	.600000	.730000	.01000W	1.410000	43.100000	5.710000	.14000T
LH138	5/21/80	1230	1.	.100000	2.240000	.01000W	1.820000	25.200000	3.210000	.12000T
LH139	5/21/80	1320	1.	.100000	.640000	.08000T	.500000	2.580000	.990000	.150000
LH144	5/18/80	0930	1.	.280000	2.240000	.09000T	.030000	5.020000	1.440000	.030000

CRUISE 3

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO	TOTAL CR	TOTAL CU	TOTAL FE	TOTAL MN	TOTAL AS
LH9	5/29/80	0327	1.	.040000	.600000	.140000	.550000	25.000000	2.220000	.300000
LH9	5/29/80	0327	30.	.040000	.580000	.09000T	1.020000	25.600000	6.360000	.120000
LH9	5/29/80	0327	49.	.01000W	.15000W	.01000W	.11000T	2.240000	.310000	.01000W
LH43	6/03/80	0101	1.	.020000	1.290000	.01000W	.410000	6.170000	1.570000	.080000
LH43	6/03/80	0101	88.	.020000	1.380000	.130000	1.050000	4.820000	2.370000	.170000
LH43	6/03/80	0101	166.	.01000W	.620000	.160000	.310000	.990000	.080000	.160000
LH44	6/02/80	1943	1.	.020000	.15000W	.01000W	.150000	4.930000	1.970000	.140000
LH44	6/02/80	1943	81.	.020000	1.590000	.110000	.910000	4.610000	2.870000	.170000
LH44	6/02/80	1943	154.	.040000	.540000	.03000T	.240000	1.090000	.100000	.230000
LH78	6/05/80	0117	1.	.01000W	.490000	.170000	.10000W	29.000000	5.870000	.190000
LH78	6/05/80	0117	12.	.01000W	.560000	.130000	.17000T	28.500000	6.070000	.190000
LH78	6/05/80	0117	35.	.01000W	.15000W	.01000W	.13000T	1.930000	.04000W	.01000W
LH78	6/05/80	0117	43.	.120000	.490000	.09000T	.10000W	51.700000	12.300000	.070000
LH80	6/05/80	0340	1.	.220000	.580000	.150000	1.360000	17.000000	5.870000	.100000
LH81	6/05/80	0428	1.	.170000	.15000W	.07000T	1.280000	28.400000	5.870000	.120000
LH81	6/05/80	0428	16.	.150000	.310000	.06000T	1.500000	26.300000	5.710000	.120000
LH81	6/05/80	0428	22.	.01000W	.15000W	.06000T	.290000	1.860000	.150000	.080000
LH82	6/05/80	0535	1.	.040000	1.240000	.330000	1.170000	22.800000	2.440000	.050000
LH83	6/05/80	1049	1.	.070000	.19000T	.350000	1.070000	8.730000	1.640000	.110000
LH84	6/05/80	1140	1.	.070000	.26000T	.160000	1.450000	13.300000	3.310000	.120000
LH84	6/05/80	1140	6.	.050000	.15000W	.09000T	1.380000	18.200000	3.300000	.110000
LH84	6/05/80	1140	13.	.020000	.15000W	.050000	.190000	2.880000	.280000	.040000
LH85	6/05/80	1236	1.	.040000	.15000W	.200000	.940000	16.500000	4.240000	.130000
LH86	6/05/80	1330	1.	.120000	1.360000	.130000	.760000	4.800000	2.090000	.170000
LH87	6/05/80	1439	1.	.090000	.15000W	.140000	.690000	8.130000	2.920000	.130000
LH87	6/05/80	1439	5.	.120000	.15000W	.150000	1.450000	10.000000	2.440000	.190000
LH87	6/05/80	1439	11.	.070000	.17000T	.01000W	.100000	5.130000	.330000	.100000
LH88	6/05/80	1654	1.	.100000	.460000	.190000	1.070000	9.130000	1.720000	.170000
LH89	6/05/80	1535	1.	.100000	.15000W	.05000T	.790000	9.630000	1.680000	.130000
LH89	6/05/80	1535	6.	.020000	.15000W	.05000T	.790000	9.630000	1.850000	.100000
LH89	6/05/80	1535	20.	.040000	.370000	.08000T	.320000	2.560000	.120000	.100000

CRUISE 4

STATION	DATE	EST TIME	DEPTH	TOTAL AG (UG/L)	TOTAL CO (UG/L)	TOTAL CR (UG/L)	TOTAL CU (UG/L)	TOTAL FE (UG/L)	TOTAL MN (UG/L)	TOTAL AS (UG/L)
LH69	7/25/80	2000	1.	.01000W	.04000T	.040000	1.520000	96.900000	2.990000	.260000
LH70	7/25/80	2225	1.	.02000T	.980000	.02000W	1.120000	25.800000	3.600000	.250000
LH72	7/25/80	0045	1.	.04000T	1.200000	.02000W	1.260000	15.000000	3.470000	.260000
LH73	7/26/80	0220	1.	.050000	1.480000	.03000T	2.140000	7.100000	2.990000	.210000
LH74	7/26/80	0815	1.	.01000W	1.520000	.100000	1.210000	6.760000	2.520000	.170000
LH75	7/26/80	0415	1.	.02000T	1.050000	.05000T	1.320000	6.650000	1.870000	.160000
LH76	7/26/80	0510	1.	.04000T	1.370000	.130000	1.550000	7.100000	3.090000	.140000
LH77	7/26/80	0700	1.	.01000W	2.170000	.260000	.670000	5.030000	.820000	.130000
LH78	7/26/80	0935	1.	.180000	1.790000	.340000	2.740000	7.270000	2.870000	.180000
LH79	7/26/80	1045	1.	.02000T	1.910000	.04000T	2.150000	7.240000	4.380000	.110000
LH80	7/26/80	1140	1.	.02000T	1.210000	.02000W	1.260000	5.370000	3.070000	.180000
LH81	7/26/80	1239	1.	.02000T	1.160000	.02000W	.280000	4.310000	3.120000	.140000
LH86	7/26/80	1750	1.	.01000W	1.130000	.070000	.330000	8.090000	3.040000	.200000
LH101	7/29/80	0340	1.	.01000W	.810000	.810000	1.150000	6.400000	.620000	.140000
LH102	7/29/80	1249	1.	.01000W	.810000	.02000W	1.420000	4.370000	.470000	.00100W
LH103	7/29/80	0150	1.	.02000T	.350000	.130000	.640000	5.700000	.620000	.140000
LH104	7/28/80	2225	1.	.01000W	.900000	.160000	1.110000	4.370000	.470000	.100000
LH105	7/28/80	2100	1.	.04000T	.490000	.05000T	1.340000	4.500000	.800000	.130000
LH106	7/29/80	0040	1.	.02000T	.430000	.05000T	1.300000	.20000W	.620000	.040000
LH107	7/28/80	2100	1.	.01000W	.13000W	.130000	1.170000	.20000W	.640000	.190000
LH108	7/28/80	1543	1.	.060000	.18000W	.03000W	.130000	2.970000	1.490000	.130000
LH109	7/28/80	1955	1.	.01000W	.10000W	.02000W	.400000	9.870000	1.180000	.130000
LH110	7/28/80	1445	1.	.060000	.10000W	.02000T	.11000T	3.010000	1.470000	.080000
LH111	7/29/80	1529	1.	.01000W	.20000T	.070000	.550000	1.700000	.620000	.00100W
LH112	7/29/80	1415	1.	.02000T	.460000	1.130000	1.310000	5.700000	.470000	.00100W
~~LH113~~	~~7/29/80~~	~~1748~~	~~1.~~	~~.01000W~~	~~.460000~~	~~.200000~~	~~.470000~~	~~1.050000~~	~~.620000~~	~~.120000~~
LH114	7/28/80	1203	1.	.01000W	.10000W	.03000W	.15000T	2.450000	.390000	.120000
LH116	7/28/80	1025	1.	.050000	.27000T	.130000	.260000	4.020000	1.730000	.120000
LH117	7/29/80	2246	1.	.04000T	.580000	.31000T	.380000	3.150000	.740000	.120000
LH118	7/29/80	2121	1.	.03000T	.580000	.02000W	.910000	4.260000	.740000	.120000
LH119	7/29/80	1950	1.	.01000W	.350000	.140000	.710000	.54000T	.350000	.150000
LH120	7/30/80	0130	1.	.01000W	.580000	.090000	.10000W	2.030000	.800000	.120000
LH121	7/30/80	0320	1.	.01000W	.530000	.01000W	.380000	2.590000	.540000	.120000
LH122	7/28/80	0640	1.	.02000T	.22000T	.660000	.320000	2.010000	.390000	.180000
LH123	7/28/80	0810	1.	.050000	.870000	.260000	.20000T	2.120000	.740000	.280000
LH124	7/27/80	1725	1.	.02000T	1.280000	.350000	.750000	4.020000	1.140000	.130000
LH126	7/27/80	1534	1.	.01000W	1.120000	.02000W	.240000	6.980000	2.540000	.120000
LH130	7/28/80	0310	1.	.070000	.19000W	.100000	.410000	.59000T	.620000	.100000
LH133	7/28/80	0125	1.	.03000T	.23000T	.070000	.11000T	3.060000	.060000	.160000
LH134	7/28/80	2320	1.	.01000W	.510000	.110000	.13000T	1.250000	.680000	.170000
LH135	7/27/80	2520	1.	.04000T	.10000W	.100000	.10000W	2.460000	.630000	.200000
LH136	7/27/80	2150	1.	.02000T	.10000W	.02000W	.120000	2.590000	1.310000	.130000
LH137	7/27/80	2025	1.	.01000W	1.270000	.02000W	.340000	3.380000	.890000	.060000
LH138	7/27/80	1403	1.	.01000W	1.140000	.02000W	.10000W	2.040000	2.390000	.210000
LH143	7/27/80	0720	1.	.01000W	1.780000	.02000W	1.380000	3.240000	1.970000	.110000
LH150	7/28/80	0510	1.	.01000W	.23000T	.110000	1.170000	2.450000	.390000	.110000

APPENDIX 2

Great Lakes Research Division

Lake Huron (1980) Trace Metal Results for Water

STATION	DATE	EST TIME	DEPTH	TOTAL FE	<.5 FE	<.2 FE	>.5 FE	UG/L >.2 FE	TOTAL AG	<.5 AG	<.2 AG	>.5 AG	>.2AG
LH001	7/18/80	1230	1.	9.310000	2.660000	-0.	6.500000	-0.	.024000	.017000	-0.	.000678	-0.
LH001	7/18/80	1230	1.	14.910000	3.960000	-0.	18.000000	-0.	.017000	.015000	-0.	.001100	-0.
LH008	7/19/80	0140	1.	10.910000	1.860000	3.260000	23.000000	14.000000	.022000	.00460T	.016000	.001290	.001320
LH010	7/19/80	0650	1.	21.910000	10.960000	-0.	15.000000	-0.	.013000	.005400	-0.	.001040	-0.
LH016	7/20/80	0215	1.	2.410000	.05900T	.720000	2.800000	3.900000	.014000	.003400	.007300	.000895	.001020
LH021	7/20/80	1115	1.	4.710000	5.060000	-0.	6.400000	-0.	.008900	.004600	-0.	.000882	-0.
LH032	7/20/80	2145	1.	3.410000	.800000	.660000	12.000000	2.700000	.011000	.003500	.006200	.000679	.002060
LH035	7/21/80	1010	1.	4.810000	.15000T	-0.	6.500000	-0.	.00037T	.00012T	-0.	.000932	-0.
LH039	7/22/80	1015	1.	2.710000	.200000	-0.	4.000000	-0.	.00440T	.00120T	-0.	.003130	-0.
LH042	7/23/80	1145	1.	2.910000	.960000	.790000	3.600000	6.500000	.009000	.00200T	0.T	.001570	.001820
LH044	7/23/80	0050	1.	1.810000	1.060000	-0.	4.400000	-0.	.010000	.007900	-0.	.000666	-0.
LH044	7/23/80	0050	1.	2.210000	.960000	-0.	21.000000	-0.	.007200	.005900	-0.	.001280	-0.
LH047	7/23/80	2340	1.	7.310000	0.T	-0.	3.900000	-0.	.005100	.01200T	-0.	.001500	-0.
LH052	7/23/80	1840	1.	2.110000	.760000	-0.	5.600000	-0.	.00069T	.00470T	-0.	.000895	-0.
LH061	7/24/80	1423	1.	6.910000	2.160000	-0.	4.700000	-0.	.019000	.008800	-0.	.001270	-0.
LH061	7/24/80	1423	1.	7.210000	1.660000	-0.	15.000000	-0.	.042000	.007700	-0.	.001200	-0.
LH071	7/25/80	2235	1.	24.910000	4.660000	-0.	8.900000	-0.	.005300	.01300T	-0.	.001790	-0.
LH077	7/26/80	0540	1.	5.310000	.12000T	-0.	7.400000	-0.	.00080T	.00420T	-0.	.000896	-0.
LH084	7/26/80	1445	1.	5.010000	.380000	1.560000	5.300000	8.100000	.00019T	.011000	.005800	.001660	.001490
LH104	7/28/80	2124	1.	5.010000	.10000T	-0.	11.000000	-0.	.014000	.016000	-0.	.002140	-0.
LH114	7/28/80	1104	1.	3.110000	.200000	-0.	2.200000	-0.	.011000	.005800	-0.	.001730	-0.
LH125	7/27/80	1530	1.	3.210000	.11000T	-0.	5.100000	-0.	.008700	.006000	-0.	.001920	-0.
LH130	7/28/80	0210	1.	1.410000	.07000T	.250000	2.100000	4.200000	.003400	.005800	.005700	.001280	.002240

STATION	DATE	EST TIME	DEPTH	TOTAL AL	<.5 AL	<.2 AL	>.5 AL	UG/L >.2 AL	TOTAL AS	<.5 AS	<.2 AS	>.5 AS	>.2AS
LH001	7/18/80	1230	1.	12.108000	13.108000	-0.	44.000000	-0.	.170000	.230000	-0.	.01100T	-0.
LH001	7/18/80	1230	1.	17.108000	4.008000	-0.	49.000000	-0.	.270000	.059000	-0.	.00970T	-0.
LH008	7/19/80	0140	1.	6.508000	2.808000	5.508000	72.000000	81.000000	.310000	.240000	0.T	.008630	.030100
LH010	7/19/80	0650	1.	21.108000	16.108000	-0.	57.000000	-0.	.270000	.250000	-0.	.012900	-0.
LH016	7/20/80	0215	1.	10.108000	1.208000	1.078000	21.000000	18.000000	.210000	.210000	.290000	.00192T	.01400T
LH021	7/20/80	1115	1.	6.408000	38.108000	-0.	46.000000	-0.	.270000	.340000	-0.	.00517T	-0.
LH032	7/20/80	2145	1.	4.608000	3.008000	.348000	15.000000	20.000000	.530000	.470000	.500000	.012500	.00563T
LH035	7/21/80	1010	1.	20.108000	5.608000	-0.	10.000000	-0.	.280000	.310000	-0.	.00203T	-0.
LH039	7/22/80	1015	1.	18.108000	1.908000	-0.	7.100000	-0.	.300000	.270000	-0.	.008740	-0.
LH042	7/23/80	1145	1.	3.808000	1.208000	3.208000	23.000000	24.000000	.490000	.310000	.400000	.00659T	.00605T
LH044	7/23/80	0050	1.	6.908000	5.008000	-0.	25.000000	-0.	.370000	.580000	-0.	.01080T	-0.
LH044	7/23/80	0050	1.	8.808000	2.208000	-0.	24.000000	-0.	.240000	0.T	-0.	.012400	-0.
LH047	7/23/80	2340	1.	12.108000	.858000	-0.	12.000000	-0.	.120000	.280000	-0.	.009830	-0.
LH052	7/23/80	1840	1.	2.508000	.658000	-0.	3.600000	-0.	.410000	0.T	-0.	.00110T	-0.
LH061	7/24/80	1423	1.	26.108000	6.608000	-0.	13.000000	-0.	.200000	0.T	-0.	.00622T	-0.
LH061	7/24/80	1423	1.	8.508000	8.308000	-0.	18.000000	-0.	.210000	0.T	-0.	.007750	-0.
LH071	7/25/80	2235	1.	21.108000	5.008000	-0.	57.000000	-0.	.180000	.750000	-0.	.00052T	-0.
LH077	7/26/80	0540	1.	7.208000	1.308000	-0.	14.000000	-0.	.140000	.360000	-0.	.00263T	-0.
LH084	7/26/80	1445	1.	9.608000	3.108000	5.808000	9.500000	13.000000	.160000	.120000	.140000	.01540T	.00699T
LH104	7/28/80	2124	1.	12.108000	3.008000	-0.	14.000000	-0.	.140000	0.T	-0.	.01700T	-0.
LH114	7/28/80	1104	1.	8.608000	3.808000	-0.	2.90000T	-0.	.072000	.270000	-0.	.00452T	-0.
LH125	7/27/80	1530	1.	6.808000	1.408000	-0.	6.900000	-0.	.210000	.120000	-0.	.009770	-0.
LH130	7/28/80	0210	1.	7.708000	8.908000	1.808000	5.600000	7.700000	.120000	.260000	.410000	.008150	.00429T

STATION	DATE	EST TIME	DEPTH	TOTAL CD	<.5 CD	<.2 CD	>.5 CD	UG/L >.2 CD	TOTAL CR	<.5 CR	<.2 CR	>.5 CR	>.2CR
LH001	7/18/80	1230	1.	.018700	.00120T	-0.	.006600	-0.	.152350	.122350	-0.	.012000	-0.
LH001	7/18/80	1230	1.	.008700	.00330T	-0.	0.T	-0.	.172350	.070350	-0.	.007900	-0.
LH008	7/19/80	0140	1.	.038700	.017100	.00100T	.150000	0.T	.087350	.00435T	.172350	.013000	.035000
LH010	7/19/80	0650	1.	.032700	.046100	-0.	.001600	-0.	.162350	.162350	-0.	.006100	-0.
LH016	7/20/80	0215	1.	.015700	0.T	.027100	.003400	.004200	.152350	.122350	.512350	.005800	.014000
LH021	7/20/80	1115	1.	.009700	0.T	-0.	.048000	-0.	.172350	.382350	-0.	.027000	-0.
LH032	7/20/80	2145	1.	.014700	0.T	0.T	.019000	0.T	.056350	.202350	.03440T	.014000	.013000
LH035	7/21/80	1010	1.	.015700	0.T	-0.	.038000	-0.	.192350	.152350	-0.	.068000	-0.
LH039	7/22/80	1015	1.	.008700	0.T	-0.	.00082T	-0.	.172350	.142350	-0.	.013000	-0.
LH042	7/23/80	1145	1.	.00170T	0.T	0.T	.006800	0.T	.132350	.142350	.079350	.030000	.014000
LH044	7/23/80	0050	1.	.010700	0.T	-0.	.013000	-0.	.032350	.02240T	-0.	.022000	-0.
LH044	7/23/80	0050	1.	.008700	0.T	-0.	.011000	-0.	.047350	.122350	-0.	.027000	-0.
LH047	7/23/80	2340	1.	.024700	.00390T	-0.	.037000	-0.	.089350	.045350	-0.	.020000	-0.
LH052	7/23/80	1840	1.	.013700	.00240T	-0.	.022000	-0.	.091350	.085350	-0.	.013000	-0.
LH061	7/24/80	1423	1.	.060700	.00510T	-0.	.012000	-0.	.122350	.056350	-0.	.023000	-0.
LH061	7/24/80	1423	1.	.00550T	0.T	-0.	.005300	-0.	.142350	.063350	-0.	.013000	-0.
LH071	7/25/80	2235	1.	.014700	0.T	-0.	.020000	-0.	.132350	.122350	-0.	.041000	-0.
LH077	7/26/80	0540	1.	.014700	0.T	-0.	.007000	-0.	.066350	.069350	-0.	.023000	-0.
LH084	7/26/80	1445	1.	.015700	.00150T	0.T	0.T	.003400	.112350	.102350	.057350	.018000	.008200
LH104	7/28/80	2124	1.	.00470T	0.T	-0.	.026000	-0.	.132350	.112350	-0.	.017000	-0.
LH114	7/28/80	1104	1.	.016700	.00710T	-0.	.002500	-0.	.122350	.162350	-0.	.012000	-0.
LH125	7/27/80	1530	1.	.005800	.00030T	-0.	.041000	-0.	.082350	.092350	-0.	.045000	-0.
LH130	7/28/80	0210	1.	.007600	0.T	0.T	.014000	0.T	.142350	.02440T	.03240T	.015000	.019000

STATION	DATE	EST TIME	DEPTH	TOTAL CU	<.5 CU	<.2 CU	>.5 CU	UG/L >.2 CU	TOTAL HG	<.5 HG	<.2 HG	>.5 HG	>.2HG
LH001	7/18/80	1230	1.	.230000	.094000	-0.	.014000	-0.	0.T	0.T	-0.	-0.	-0.
LH001	7/18/80	1230	1.	.220000	.063000	-0.	.038000	-0.	0.T	0.T	-0.	-0.	-0.
LH008	7/19/80	0140	1.	.480000	.260000	.420000	.048000	.098000	.00920T	.360000	-0.	-0.	-0.
LH010	7/19/80	0650	1.	.230000	.200000	-0.	.066000	-0.	.097000	.00420T	-0.	-0.	-0.
LH016	7/20/80	0215	1.	.360000	.250000	.300000	.082000	.130000	.097000	0.T	-0.	-0.	-0.
LH021	7/20/80	1115	1.	.380000	.260000	-0.	.390000	-0.	.00740T	.03000T	-0.	-0.	-0.
LH032	7/20/80	2145	1.	.340000	.280000	.210000	.260000	.035000	0.T	0.T	-0.	-0.	-0.
LH035	7/21/80	1010	1.	.310000	.220000	-0.	.660000	-0.	0.T	.03800T	-0.	-0.	-0.
LH039	7/22/80	1015	1.	.220000	.180000	-0.	.990000	-0.	0.T	.08800T	-0.	-0.	-0.
LH042	7/23/80	1145	1.	.540000	.440000	.490000	.210000	.550000	.200000	.03600T	-0.	-0.	-0.
LH044	7/23/80	0050	1.	.500000	.300000	-0.	.067000	-0.	0.T	.140000	-0.	-0.	-0.
LH044	7/23/80	0050	1.	.420000	.340000	-0.	.067000	-0.	.210000	.250000	-0.	-0.	-0.
LH047	7/23/80	2340	1.	.380000	.260000	-0.	.430000	-0.	.350000	.01800T	-0.	-0.	-0.
LH052	7/23/80	1840	1.	.400000	.380000	-0.	19.700000	-0.	.150000	.04300T	-0.	-0.	-0.
LH061	7/24/80	1423	1.	1.700000	.480000	-0.	1.300000	-0.	.100000	.10000T	-0.	-0.	-0.
LH061	7/24/80	1423	1.	1.600000	.340000	-0.	.880000	-0.	.01300T	0.T	-0.	-0.	-0.
LH071	7/25/80	2235	1.	.550000	.570000	-0.	.580000	-0.	.01100T	0.T	-0.	-0.	-0.
LH077	7/26/80	0540	1.	.610000	.370000	-0.	.160000	-0.	.01700T	0.T	-0.	-0.	-0.
LH084	7/26/80	1445	1.	.640000	.500000	.620000	.120000	.790000	.099000	.03500T	-0.	-0.	-0.
LH104	7/28/80	2124	1.	.320000	.220000	-0.	.120000	-0.	0.T	0.T	-0.	-0.	-0.
LH114	7/28/80	1104	1.	.470000	.300000	-0.	.074000	-0.	.01200T	0.T	-0.	-0.	-0.
LH125	7/27/80	1530	1.	.560000	.430000	-0.	.220000	-0.	.00140T	0.T	-0.	-0.	-0.
LH130	7/28/80	0210	1.	.570000	.350000	.360000	.120000	.043000	0.T	0.T	-0.	-0.	-0.

STATION	DATE	EST TIME	DEPTH	TOTAL MN	<.5 MN	<.2 MN	>.5 MN	UG/L >.2 MN	TOTAL NI	<.5 NI	<.2 NI	>.5 NI	>.2NI
LH001	7/18/80	1230	1.	.670000	.330000	-0.	.380200	-0.	.510000	.730000	-0.	.021000	-0.
LH001	7/18/80	1230	1.	.730000	.260000	-0.	.720200	-0.	.330000	.530000	-0.	.025000	-0.
LH008	7/19/80	0140	1.	1.100000	.300000	.350000	.450200	1.520200	.440000	.400000	.430000	0.T	.001300
LH010	7/19/80	0650	1.	1.000000	.640000	-0.	.500200	-0.	.310000	.490000	-0.	.00070T	-0.
LH016	7/20/80	0215	1.	.700000	.300000	.310000	.250200	.840200	.590000	.420000	.380000	.027000	0.T
LH021	7/20/80	1115	1.	1.200000	.160000	-0.	1.420200	-0.	.480000	.480000	-0.	.040000	-0.
LH032	7/20/80	2145	1.	.610000	.280000	.280000	.410200	.200200	.380000	.190000	.330000	.011000	0.T
LH035	7/21/80	1010	1.	.820000	.280000	-0.	1.120200	-0.	.540000	.450000	-0.	.034000	-0.
LH039	7/22/80	1015	1.	.650000	.300000	-0.	.210200	-0.	.540000	.470000	-0.	0.T	-0.
LH042	7/23/80	1145	1.	.640000	.310000	.250000	.710200	.290200	.410000	.310000	.470000	.070000	0.T
LH044	7/23/80	0050	1.	.620000	.220000	-0.	.580200	-0.	.540000	.410000	-0.	.022000	-0.
LH044	7/23/80	0050	1.	.650000	.220000	-0.	.250200	-0.	.420000	.380000	-0.	.037000	-0.
LH047	7/23/80	2340	1.	.670000	.140000	-0.	.350200	-0.	.450000	.280000	-0.	.044000	-0.
LH052	7/23/80	1840	1.	.550000	.320000	-0.	.290200	-0.	.580000	.520000	-0.	.037000	-0.
LH061	7/24/80	1423	1.	.580000	.250000	-0.	.180200	-0.	.740000	.500000	-0.	.025000	-0.
LH061	7/24/80	1423	1.	.580000	.260000	-0.	.670200	-0.	.690000	.730000	-0.	.00400T	-0.
LH071	7/25/80	2235	1.	.250000	.470000	-0.	3.020200	-0.	.960000	.620000	-0.	.086000	-0.
LH077	7/26/80	0540	1.	.850000	.120000	-0.	.920200	-0.	2.100000	.980000	-0.	.058000	-0.
LH084	7/26/80	1445	1.	.960000	.210000	.250000	1.020200	1.120200	3.800000	2.800000	3.400000	.042000	.130000
LH104	7/28/80	2124	1.	.850000	.120000	-0.	1.020200	-0.	.580000	.360000	-0.	.043000	-0.
LH114	7/28/80	1104	1.	.700000	.200000	-0.	.590200	-0.	1.200000	.870000	-0.	.042000	-0.
LH125	7/27/80	1530	1.	1.100000	.300000	-0.	1.420200	-0.	1.500000	1.200000	-0.	.074000	-0.
LH130	7/28/80	0210	1.	.560000	.290000	.300000	.420200	.170200	1.000000	.660000	.630000	.021000	.066000

STATION	DATE	EST TIME	DEPTH	TOTAL PB	<.5 PB	<.2 PB	>.5 PB	UG/L >.2 PB	TOTAL SE	<.5 SE	<.2 SE	>.5 SE	>.2SE
LH001	7/18/80	1230	1.	.02100T	.031000	-0.	.018000	-0.	.160000	.410000	-0.	0.T	-0.
LH001	7/18/80	1230	1.	.01000T	0.T	-0.	.040000	-0.	.410000	.096000	-0.	0.T	-0.
LH008	7/19/80	0140	1.	0.T	.02300T	0.T	.051000	.038000	1.200000	.440000	.770000	0.T	0.T
LH010	7/19/80	0650	1.	0.T	.02300T	-0.	.015000	-0.	.860000	.450000	-0.	0.T	-0.
LH016	7/20/80	0215	1.	.01800T	.053000	-0.	.00950T	.028000	.340000	.430000	.530000	0.T	0.T
LH021	7/20/80	1115	1.	.063000	.080000	-0.	.072000	-0.	.480000	.580000	-0.	0.T	-0.
LH032	7/20/80	2145	1.	.100000	.044000	.043000	.100000	.00500T	.620000	.420000	.460000	0.T	0.T
LH035	7/21/80	1010	1.	.100000	.081000	-0.	.110000	-0.	.400000	.670000	-0.	0.T	-0.
LH039	7/22/80	1015	1.	.01200T	-0.	-0.	.026000	-0.	.390000	.580000	-0.	0.T	-0.
LH042	7/23/80	1145	1.	.01900T	.01500T	.067000	.023000	.061000	.530000	1.000000	.670000	0.T	0.T
LH044	7/23/80	0050	1.	.100000	.030000	-0.	.042000	-0.	.430000	.480000	-0.	0.T	-0.
LH044	7/23/80	0050	1.	.01600T	.01000T	-0.	.084000	-0.	.400000	.320000	-0.	0.T	-0.
LH047	7/23/80	2340	1.	.02000T	0.T	-0.	.041000	-0.	.530000	.580000	-0.	0.T	-0.
LH052	7/23/80	1840	1.	.110000	0.T	-0.	.083000	-0.	.530000	.670000	-0.	0.T	-0.
LH061	7/24/80	1423	1.	.051000	.00890T	-0.	.140000	-0.	.420000	.580000	-0.	0.T	-0.
LH061	7/24/80	1423	1.	0.T	-0.	-0.	.029000	-0.	.580000	.530000	-0.	0.T	-0.
LH071	7/25/80	2235	1.	.042000	0.T	-0.	.055000	-0.	.480000	.400000	-0.	0.T	-0.
LH077	7/26/80	0540	1.	.02200T	0.T	-0.	.016000	-0.	.360000	.240000	-0.	0.T	-0.
LH084	7/26/80	1445	1.	.02200T	0.T	0.T	.042000	.015000	.410000	.370000	.440000	0.T	0.T
LH104	7/28/80	2124	1.	.057000	0.T	-0.	.072000	-0.	.530000	.370000	-0.	0.T	-0.
LH114	7/28/80	1104	1.	.039000	0.T	-0.	.024000	-0.	.620000	.770000	-0.	0.T	-0.
LH125	7/27/80	1530	1.	.02800T	0.T	-0.	.039000	-0.	.480000	.770000	-0.	0.T	-0.
LH130	7/28/80	0210	1.	.02100T	0.T	0.T	.031000	.044000	.460000	.770000	.380000	0.T	0.T

STATION	DATE	EST TIME	DEPTH	TOTAL V	<.5 V	<.2 V	>.5 V	UG/L >.2 V	TOTAL ZN	<.5 ZN	<.2 ZN	>.5 ZN	>.2ZN
LH001	7/18/80	1230	1.	.407600	.145300	-0.	.016000	-0.	.210000	.08500T	-0.	.06500T	-0.
LH001	7/18/80	1230	1.	.227600	.125300	-0.	.022000	-0.	.250000	.17000T	-0.	.13000T	-0.
LH008	7/19/80	0140	1.	.187600	.109300	.087300	.025000	.026000	.200000	.02600T	.190000	.340000	.350000
LH010	7/19/80	0650	1.	.217600	.155300	-0.	.017000	-0.	.380000	.500000	-0.	.180000	-0.
LH016	7/20/80	0215	1.	1.117600	.405300	.915300	.00870T	.01300T	.400000	.560000	5.980000	.330000	.220000
LH021	7/20/80	1115	1.	.177600	.235300	-0.	.015000	-0.	.240000	.14000T	-0.	.510000	-0.
LH032	7/20/80	2145	1.	.207600	.165300	-0.	.013000	.01100T	.310000	.810000	.14000T	.490000	.270000
LH035	7/21/80	1010	1.	.127600	.505300	-0.	.012000	-0.	.510000	.06800T	-0.	.900000	-0.
LH039	7/22/80	1015	1.	.177600	.475300	-0.	.010000	-0.	.220000	.270000	-0.	.910000	-0.
LH042	7/23/80	1145	1.	.327600	.145300	.235300	.01300T	.01200T	.300000	.13000T	.18000T	.390000	2.130000
LH044	7/23/80	0050	1.	.267600	.205300	-0.	.00910T	-0.	.280000	.15000T	-0.	.190000	-0.
LH044	7/23/80	0050	1.	.137600	.155300	-0.	.00810T	-0.	.240000	.460000	-0.	.320000	-0.
LH047	7/23/80	2340	1.	.317600	.605300	-0.	.00790T	-0.	.380000	.17000T	-0.	.750000	-0.
LH052	7/23/80	1840	1.	.357600	.255300	-0.	.008000	-0.	.290000	.16000T	-0.	9.610000	-0.
LH061	7/24/80	1423	1.	.207600	.245300	-0.	.016000	-0.	2.800000	2.300000	-0.	.058000	-0.
LH061	7/24/80	1423	1.	.597600	.235300	-0.	.014000	-0.	.790000	.250000	-0.	.330000	-0.
LH071	7/25/80	2235	1.	.327600	.345300	-0.	.083000	-0.	.510000	.270000	-0.	1.100000	-0.
LH077	7/26/80	0540	1.	.547600	.305300	-0.	.020000	-0.	.320000	.240000	-0.	.170000	-0.
LH084	7/26/80	1445	1.	.116600	.265300	-0.	.023000	.01200T	.560000	.340000	.240000	.710000	.380000
LH104	7/28/80	2124	1.	.167600	.225300	-0.	.026000	-0.	.12000T	.13000T	-0.	.380000	-0.
LH114	7/28/80	1104	1.	.247600	.385300	-0.	.00260T	-0.	.210000	.400000	-0.	.230000	-0.
LH125	7/27/80	1530	1.	.100600	.555300	-0.	.014000	-0.	.190000	.12000T	-0.	.180000	-0.
LH130	7/28/80	0210	1.	.157600	.145300	.355300	.016000	.00740T	.390000	.330000	.07200T	.13000T	.330000